# Assessing the Toxicity and Bioaccumulation Impacts of Metals-Contaminated Sediments in the Upper Sacramento River Watershed

## Project Information

1. **Proposal Title:**

   Assessing the Toxicity and Bioaccumulation Impacts of Metals-Contaminated Sediments in the Upper Sacramento River Watershed

2. **Proposal applicants:**

   Richard Ogle, Pacific EcoRisk
   Charlie Alpers, U.S. Geological Survey

3. **Corresponding Contact Person:**

   Richard Ogle
   Pacific EcoRisk
   835 Arnold Dr., Suite 104 Martinez, CA 94553
   925 313-8080
   scottogle@pacificecorisk.com

4. **Project Keywords:**

   **Contaminants**
   **Heavy Metals (mercury, selenium, etc.)**
   **Sediment quality**

5. **Type of project:**

   Research

6. **Does the project involve land acquisition, either in fee or through a conservation easement?**

   No

7. **Topic Area**:

   Ecosystem Water and Sediment Quality

8. **Type of applicant:**

   Joint Venture

9. **Location - GIS coordinates:**

Latitude:

Longitude:

Datum:

**Describe project location using information such as water bodies, river miles, road intersections, landmarks, and size in acres.**

Upper Sacramento River and selected tributaries

10. **Location - Ecozone:**

    3.1 Keswick Dam to Red Bluff Diversion Dam, 3.2 Red Bluff Diversion Dam to Chico Landing, 3.3 Chico Landing to Colusa, 4.1 Clear Creek, 4.2 Cow Creek, 4.3 Bear Creek, 4.4 Battle Creek, 5.2 Lower Cottonwood Creek, 6.1 Stony Creek, 6.2 Elder Creek, 6.3 Thomas Creek, 6.4 Colusa Basin, 7.3 Mill Creek, 7.4 Deer Creek, 7.5 Big Chico Creek, 7.6 Butte Creek, Code 15: Landscape

11. **Location - County:**

    Butte, Colusa, Glenn, Shasta, Sutter, Tehama, Yolo

12. **Location - City:**

    Does your project fall within a city jurisdiction?

    No

13. **Location - Tribal Lands:**

    Does your project fall on or adjacent to tribal lands?

    No

14. **Location - Congressional District:**

    3RD

15. **Location:**

    **California State Senate District Number:** 4

    **California Assembly District Number:** 2

16. **How many years of funding are you requesting?**

    3

17. **Requested Funds:**
    a) Are your overhead rates different depending on whether funds are state or federal?

       No

If no, list single overhead rate and total requested funds:

Single Overhead Rate: 118

Total Requested Funds: 743,593

b) Do you have cost share partners already identified?

No

c) Do you have potential cost share partners?

**No**

d) Are you specifically seeking non-federal cost share funds through this solicitation?

No

If the total non-federal cost share funds requested above does not match the total state funds requested in 17a, please explain the difference:

18. **Is this proposal for next-phase funding of an ongoing project funded by CALFED?**

No

Have you previously received funding from CALFED for other projects not listed above?

**No**

19. **Is this proposal for next-phase funding of an ongoing project funded by CVPIA?**

**No**

Have you previously received funding from CVPIA for other projects not listed above?

No

20. **Is this proposal for next-phase funding of an ongoing project funded by an entity other than CALFED or CVPIA?**

No

**Please list suggested reviewers for your proposal.** (optional)

**Sam Luoma CALFED snluoma@usgs.gov**

**Mike Saiki U.S. Geological Survey 707-678-0682 michael_saiki@usgs.gov**

**Charlene Hall US Fish & Wildlife Service 916-414-6600**

| | | | |
|---|---|---|---|
| **Chris Foe** | **Central Valley Regional Water Quality Board** | **916-255-3113** | **FoeC@rb5s.swrcb.ca.gov** |

21. **Comments:**

# Environmental Compliance Checklist

## Assessing the Toxicity and Bioaccumulation Impacts of Metals-Contaminated Sediments in the Upper Sacramento River Watershed

1. **CEQA or NEPA Compliance**
   a) Will this project require compliance with CEQA?

      No
   b) Will this project require compliance with NEPA?

      No
   c) If neither CEQA or NEPA compliance is required, please explain why compliance is not required for the actions in this proposal.

      The proposed studies will not involve any construction nor any other activity that might introduce contaminants into the environment, or otherwise result in degradation of water or sediment quality.

2. **If the project will require CEQA and/or NEPA compliance, identify the lead agency(ies).** *If not applicable, put "None".*

   CEQA Lead Agency:
   NEPA Lead Agency (or co-lead:)
   NEPA Co-Lead Agency (if applicable):

3. **Please check which type of CEQA/NEPA documentation is anticipated.**

   **CEQA**
   **-**Categorical Exemption
   **-**Negative Declaration or Mitigated Negative Declaration
   **-**EIR
   **X**none

   **NEPA**
   **-**Categorical Exclusion
   **-**Environmental Assessment/FONSI
   **-**EIS
   **X**none

   If you anticipate relying on either the Categorical Exemption or Categorical Exclusion for this project, please specifically identify the exemption and/or exclusion that you believe covers this project.

4. **CEQA/NEPA Process**
   a) Is the CEQA/NEPA process complete?

      Not Applicable

   b) If the CEQA/NEPA document has been completed, please list document name(s):

5. **Environmental Permitting and Approvals** (*If a permit is not required, leave both Required? and Obtained? check boxes blank.*)

**LOCAL PERMITS AND APPROVALS**

Conditional use permit

Variance

Subdivision Map Act

Grading Permit

General Plan Amendment

Specific Plan Approval

Rezone

Williamson Act Contract Cancellation

Other

**STATE PERMITS AND APPROVALS**

Scientific Collecting Permit

CESA Compliance: 2081

CESA Compliance: NCCP

1601/03

CWA 401 certification

Coastal Development Permit

Reclamation Board Approval

Notification of DPC or BCDC

Other

**FEDERAL PERMITS AND APPROVALS**

ESA Compliance Section 7 Consultation

ESA Compliance Section 10 Permit

Rivers and Harbors Act

CWA 404

Other

**PERMISSION TO ACCESS PROPERTY**

Permission to access city, county or other local agency land.
Agency Name:

Permission to access state land.
Agency Name:

Permission to access federal land.
Agency Name:

Permission to access private land.
Landowner Name:

6. **Comments.**

# Land Use Checklist

## Assessing the Toxicity and Bioaccumulation Impacts of Metals-Contaminated Sediments in the Upper Sacramento River Watershed

1. **Does the project involve land acquisition, either in fee or through a conservation easement?**

   No

2. **Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal?**

   No

3. **Do the actions in the proposal involve physical changes in the land use?**

   **No**

   If you answered no to #3, explain what type of actions are involved in the proposal (i.e., research only, planning only).

   The proposed study is research only, with the collection of small amounts of sediments from selected samping sites within the Sacramento-San Joaquin Delta watershed.

4. **Comments.**

# Conflict of Interest Checklist

## Assessing the Toxicity and Bioaccumulation Impacts of Metals-Contaminated Sediments in the Upper Sacramento River Watershed

Please list below the full names and organizations of all individuals in the following categories:

- Applicants listed in the proposal who wrote the proposal, will be performing the tasks listed in the proposal or who will benefit financially if the proposal is funded.
- Subcontractors listed in the proposal who will perform some tasks listed in the proposal and will benefit financially if the proposal is funded.
- Individuals not listed in the proposal who helped with proposal development, for example by reviewing drafts, or by providing critical suggestions or ideas contained within the proposal.

The information provided on this form will be used to select appropriate and unbiased reviewers for your proposal.

**Applicant(s):**

Richard Ogle, Pacific EcoRisk
Charlie Alpers, U.S. Geological Survey

**Subcontractor(s):**

Are specific subcontractors identified in this proposal? No

**Helped with proposal development:**

Are there persons who helped with proposal development?

No

**Comments:**

# Budget Summary

## Assessing the Toxicity and Bioaccumulation Impacts of Metals-Contaminated Sediments in the Upper Sacramento River Watershed

Please provide a detailed budget for each year of requested funds, indicating on the form whether the indirect costs are based on the Federal overhead rate, State overhead rate, or are independent of fund source.

Independent of Fund Source

| Year 1 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Task No.** | **Task Description** | **Direct Labor Hours** | **Salary *(per year)*** | **Benefits *(per year)*** | **Travel** | **Supplies & Expendables** | **Services or Consultants** | **Equipment** | **Other Direct Costs** | **Total Direct Costs** | **Indirect Costs** | **Total Cost** |
| 1 | Identification of Metals | 310 | 10,536.4 | 3363.8 | | 700 | | | | 14600.2 | 15,112.8 | 29713.00 |
| 2 | Site Reconnaissance | 60 | 2,738 | 829.6 | 1200 | | | | 400 | 5167.6 | 4,211.6 | 9379.20 |
| 3 | Collection of Samples | 428 | 8,194.4 | 2,551.72 | 2800 | 6,000 | | 300 | 5,050 | 24896.12 | 14,036.88 | 38933.00 |
| 4 | Sediment Toxicity Testing | 30 | 714.3 | 207.6 | | | 72,000 | | | 72921.9 | 1,028.7 | 73950.60 |
| 5 | Sediment Bioaccumulation Testing | | | | | | 54,000 | | | 54000.0 | | 54000.00 |
| 6 | Sediment Benthic Community Analyses | | | | | | 27,000 | | | 27000.0 | | 27000.00 |
| 7a | Chemical Analyses of Sediments | 40 | 1154 | 378 | | | 19500 | | 100 | 21132.0 | 20,200 | 41332.00 |
| 7b | Chemical Analyses of Tissues | | | | | | 20,950 | | | 20950.0 | | 20950.00 |
| 8 | Report Preparation | 310 | 12,635 | 4,081 | | | | | | 16716.0 | 17,752 | 34468.00 |
| 9 | Project Management | 236 | 10,013.56 | 3,190.52 | 4,200 | | | | 100 | 17504.08 | 14,144.92 | 31649.00 |
| | | 1414 | 45985.66 | 14602.24 | 8200.00 | 6700.00 | 193450.00 | 300.00 | 5650.00 | 274887.90 | 86486.90 | 361374.80 |

## Year 2

| Task No. | Task Description | Direct Labor Hours | Salary *(per year)* | Benefits *(per year)* | Travel | Supplies & Expendables | Services or Consultants | Equipment | Other Direct Costs | Total Direct Costs | Indirect Costs | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Site Reconnaissance | 200 | 2,885.8 | 874.8 | 1250 | | | | 400 | 5410.6 | 4,325.99 | 9736.59 |
| 3 | Collection of Samples | 636 | 14,210.04 | 4,568.46 | 2,900 | 6,250 | | 300 | 5,275 | 33503.5 | 21,188.55 | 54692.05 |
| 4 | Sediment Toxicity Testing | 30 | 758.10 | 219.9 | | | 76,500 | | | 77478.0 | 1,092.00 | 78570.00 |
| 5 | Sediment Bioaccumulation Testing | | | | | | 57,000 | | | 57000.0 | | 57000.00 |
| 6 | Benthic Community Analyses | | | | | | 28,500 | | | 28500.0 | | 28500.00 |
| 7a | Chemical Analyses of Sediments | 40 | 1,212 | 402 | | | 39000 | | 100 | 40714.0 | 37,733.11 | 78447.11 |
| 7b | Chemical Analyses of Tissues | | | | | | 22,000 | | | 22000.0 | | 22000.00 |
| 8 | Report Preparation | 280 | 16,500.8 | 5,593.60 | | | | | | 22094.4 | 22,689.01 | 44783.41 |
| 9 | Project Management | 260 | 9,932.76 | 3,076.12 | 2,310 | | | | 100 | 15418.88 | 13,525.02 | 28943.90 |
| | | 1446 | 45499.50 | 14734.88 | 6460.00 | 6250.00 | 223000.00 | 300.00 | 5875.00 | 302119.38 | 100553.68 | 402673.06 |

## Year 3

| Task No. | Task Description | Direct Labor Hours | Salary *(per year)* | Benefits *(per year)* | Travel | Supplies & Expendables | Services or Consultants | Equipment | Other Direct Costs | Total Direct Costs | Indirect Costs | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | | | | | | | | | | 0.0 | | 0.00 |
| 8 | Report Preparation | 400 | 13,900.20 | 7,530.8 | 600 | 500 | | | 1900 | 24431.0 | 32,848.38 | 57279.38 |
| 9 | Project Management | 80 | 3,700 | 1404 | 1200 | | | | 100 | 6404.0 | 5,738.36 | 12142.36 |
| | | 480 | 17600.20 | 8934.80 | 1800.00 | 500.00 | 0.00 | 0.00 | 2000.00 | 30835.00 | 38586.74 | 69421.74 |

**Grand Total=833469.60**

**Comments.**
Please refer to Appendices A & B of the submitted proposal for budget details.

# Budget Justification

## Assessing the Toxicity and Bioaccumulation Impacts of Metals-Contaminated Sediments in the Upper Sacramento River Watershed

**Direct Labor Hours.** Provide estimated hours proposed for each individual.

Please see Appendices A & B of the submitted proposal for details of budget.

**Salary.** Provide estimated rate of compensation proposed for each individual.

Please see Appendices A & B of the submitted proposal for details of budget.

**Benefits.** Provide the overall benefit rate applicable to each category of employee proposed in the project.

Please see Appendices A & B of the submitted proposal for details of budget.

**Travel.** Provide purpose and estimate costs for all non-local travel.

Please see Appendices A & B of the submitted proposal for details of budget.

**Supplies & Expendables.** Indicate separately the amounts proposed for office, laboratory, computing, and field supplies.

Please see Appendices A & B of the submitted proposal for details of budget.

**Services or Consultants.** Identify the specific tasks for which these services would be used. Estimate amount of time required and the hourly or daily rate.

Please see Appendices A & B of the submitted proposal for details of budget.

**Equipment.** Identify non-expendable personal property having a useful life of more than one (1) year and an acquisition cost of more than $5,000 per unit. If fabrication of equipment is proposed, list parts and materials required for each, and show costs separately from the other items.

Please see Appendices A & B of the submitted proposal for details of budget.

**Project Management.** Describe the specific costs associated with insuring accomplishment of a specific project, such as inspection of work in progress, validation of costs, report preparation, giving presentatons, reponse to project specific questions and necessary costs directly associated with specific project oversight.

Please see Appendices A & B of the submitted proposal for details of budget.

**Other Direct Costs.** Provide any other direct costs not already covered.

Please see Appendices A & B of the submitted proposal for details of budget.

**Indirect Costs.** Explain what is encompassed in the overhead rate (indirect costs). Overhead should include costs associated with general office requirements such as rent, phones, furniture, general office staff, etc., generally distributed by a predetermined percentage (or surcharge) of specific costs.

Salary rates and all services (testing and analytical) foor Pacifici EcoRisk's budget are fully-loaded, with overhead incorporated into the direct costs. The overhead rate for all costs incurred by USGS are as consistent with USGS overhead rate.

# Executive Summary

## Assessing the Toxicity and Bioaccumulation Impacts of Metals-Contaminated Sediments in the Upper Sacramento River Watershed

Federal, state, and local programs aimed at improving water quality have been important steps in achieving improved water quality conditions in the Sacramento-San Joaquin Rivers, the Delta, and northern San Francisco Bay. However, the sediments of this economically and ecologically important ecosystem have not received this same attention. This is a problem as the sediments (and their associated benthic organisms) are critically important in maintaining the health and productivity of aquatic ecosystems. Sediments are the primary sink for nutrients in aquatic systems, and benthic nutrient recycling is fundamental to keeping aquatic systems alive and healthy. Furthermore, feeding studies have indicated that many of the important fish populations in the Sacramento-San Joaquin Rivers and Delta rely on benthic amphipods and insects as key food items, with some species feeding almost exclusively on benthic organisms. Unfortunately, sediments are also a major sink for both metal and organic contaminants that are introduced into these aquatic systems. For instance, historical mining activities have resulted in contamination of sediments with metals. As a result, sediments have the potential to be the most sensitive compartment in the aquatic system. Problem: Historical Mining Activities and Sediment Toxicity and Bioaccumulation of Metals in the Sacramento River Watershed Mining activities in the Sacramento River watershed have resulted in metals contamination of the Sacramento River system, and accumulation in the Rivers sediments. Benthic invertebrates collected from the river exhibit elevated tissue concentrations of Cd, Cu, Pb, and Zn. Metals contamination of sediments can result in the loss of sensitive species, and reduction in total invertebrate biomass (= less fish food) and number of species. Fish which feed upon metals-contaminated invertebrates can be adversely impacted (e.g., significant reductions in growth), and metals can limit the distribution and abundance of some fish populations. However, there has been very little evaluation of the toxicity or bioaccumulation of metals in the upper Sacramento River watershed. Given the importance of the benthos and the potential for adverse effects of these metals on salmonids, evaluation of potential sediment toxicity and bioaccumulation should be a major concern for environmental scientists and regulators. The proposed study addresses this problem, and will generate information needed to guide restoration/remediation actions. The proposed Scope of Work includes a sampling and testing program to assess the toxicity and boaccumulation of sediment metals in the upper Sacramento River watershed. Sediments will be collected from selected tributaries and main stem river stations. These sediments will be analyzed for toxicity and bioaccumulation using standard EPA totest protocol. Benthic community analyses will also be performed. The sediments and the bioaccumulation test tissues will be analyzed for metals as well as other important physical/chemical characteristics. As numerous other ongoing and proposed studies are focused on mercury distribution in the watershed, the primary emphasis of this study will be toxicity related to base metals (e.g., Cd, Cu, Ni, Pb, and Zn) however Hg and methyl-Hg will be analyzed in sediments to provide useful information to other studies. This is a proposed three year research/monitoring project that addresses primarily CALFED Strategic Goal #6 Sediment and Water Quality, but also supports Strategic Goal 1 At Risk Species, Strategic Goal 3 Harvestable Species, and Strategic Goal 4 Habitats

# Proposal

## Pacific EcoRisk

## Assessing the Toxicity and Bioaccumulation Impacts of Metals-Contaminated Sediments in the Upper Sacramento River Watershed

Richard Ogle, Pacific EcoRisk
Charlie Alpers, U.S. Geological Survey

# Assessing the Toxicity and Bioaccumulation Impacts of Metals-Contaminated Sediments in the Upper Sacramento River Watershed

**Principal Investigator:**

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**October 5, 2001**

# Assessing the Toxicity and Bioaccumulation Impacts of Metals-Contaminated Sediments in the Upper Sacramento River Watershed

## EXECUTIVE SUMMARY

Federal, state, and local programs aimed at improving water quality have been important steps in achieving improved water quality conditions in the Sacramento and San Joaquin Rivers, the Delta, and northern San Francisco Bay. However, the sediments of this economically and ecologically important ecosystem have not received this same attention. This is a problem as the sediments (and their associated benthic organisms) are critically important in maintaining the health and productivity of aquatic ecosystems. Sediments are the primary sink for nutrients in aquatic systems, and benthic nutrient recycling is fundamental to keeping aquatic systems alive and healthy. Furthermore, feeding studies have indicated that many of the important fish populations in the Sacramento and San Joaquin Rivers and the Delta rely on benthic amphipods and insects as key food items, with some species feeding almost exclusively on benthic organisms.

Unfortunately, sediments are also a major sink for both metal and organic contaminants that are introduced into these aquatic systems. For instance, historical mining activities have resulted in contamination of sediments with metals. As a result, sediments have the potential to be the most 'sensitive' compartment in the aquatic system.

**Problem: Historical Mining Activities and Sediment Toxicity and Bioaccumulation of Metals in the Sacramento River Watershed**

Mining activities in the Sacramento River watershed have resulted in metals contamination of the Sacramento River system, and accumulation in the River's sediments. Benthic invertebrates collected from the river exhibit elevated tissue concentrations of Cd, Cu, Pb, and Zn. Metals contamination of sediments can result in the loss of sensitive species, and reduction in total invertebrate biomass (= less fish food) and number of species. Fish which feed upon metals-contaminated invertebrates can be adversely impacted (e.g., significant reductions in growth), and metals can limit the distribution and abundance of some fish populations.

However, there has been very little evaluation of the toxicity or bioaccumulation of metals in the upper Sacramento River watershed. Given the importance of the benthos and the potential for adverse effects of these metals on salmonids, evaluation of potential sediment toxicity and bioaccumulation should be a major concern for environmental scientists and regulators. The proposed study addresses this problem, and will generate information needed to guide restoration/remediation actions.

The proposed Scope of Work includes a sampling and testing program to assess the toxicity and boaccumulation of sediment metals in the upper Sacramento River watershed. Sediments will be collected from selected tributaries and main stem river stations. These sediments will be analyzed for toxicity and bioaccumulation using standard EPA test protocol. Benthic community analyses will also be performed. The sediments and the bioaccumulation test tissues will be analyzed for metals as well as other important physical/chemical characteristics.

As numerous other ongoing and proposed studies are focused on mercury (Hg) distribution in the watershed, the primary emphasis of this study will be toxicity related to base metals (e.g., Cd, Cu, Ni, Pb, and Zn). However Hg and methyl-Hg will be analyzed in sediments to provide useful information to other studies.

This is a proposed three-year research/monitoring project that addresses primarily CALFED Strategic Goal #6 “Sediment and Water Quality”, but also supports Strategic Goal #1 – At Risk Species, Strategic Goal #3 – Harvestable Species, and Strategic Goal #4 – Habitats.

# Assessing the Toxicity and Bioaccumulation Impacts of Metals-Contaminated Sediments in the Upper Sacramento River Watershed

## 1.0 Statement of Problem: Introduction and Background Information

The development and implementation of federal, state, and local regulations aimed at improving the quality of freshwater and estuarine/marine ecosystems have been important steps in achieving improved ambient water quality conditions in the San Francisco Estuary watershed. As a result of the Clean Water Act (passed in 1972) and the National Pollution Discharge Elimination System (NPDES) program, point-source wastewater discharges and even non-point urban and agricultural runoff have been and continue to be monitored and evaluated, and increasingly stringent discharge limits and source reduction programs have achieved significant improvements in water quality (Davis et al. 1991; Monroe et al. 1992).

However, the sediments of aquatic ecosystems have not received this same attention. This is somewhat surprising and unfortunate, as sediments and the associated benthic organisms are critically important in maintaining the health and productivity of aquatic ecosystems. As the repository for sinking particulate matter, sediments are the primary sink for nutrients in aquatic systems, and benthic nutrient recycling is fundamental to keeping aquatic systems alive and healthy (Vannote et al. 1980; Mann 1980).

Furthermore, feeding studies have indicated that many of the important fish populations in the Sacramento-San Joaquin Rivers and Delta rely on benthic amphipods and larval insects as key food items, with some species feeding almost exclusively on benthic organisms (Schaffter et al. 1982; Daniels and Moyle 1983; Saiki and Schmitt 1985; Vogel and Marine 1991; Feyrer and Matern 2000; Sommer et al. 2000).

Unfortunately, sediments are also a major sink for contaminants, both metals and organics, that are introduced into these aquatic systems. As a result, sediments have the potential to be the most 'sensitive' compartment in the aquatic system, as well as serving as a longer-term source of these contaminants when the sediments are disturbed and mixed into the water column (by currents, dredging, bioturbation). Given the importance of the benthos and the potential for adverse effects from contaminants, evaluation of potential sediment toxicity and bioaccumulation should be a major concern for environmental scientists and regulators.

Recognizing this, regulatory-based toxicity testing of marine and estuarine sediments has become commonplace in California. There are solid phase and elutriate tests and bioaccumulation tests routinely conducted on sediments prior to dredging, ambient sediment testing was the major component of the Bay Protection and Toxic Cleanup Program, and in San Francisco Bay, ambient sediments are being tested as part of the Regional Monitoring Program, as well as the National Oceanic and Atmospheric Administration's (NOAA) Status and Trends Program.

However, there has been very little evaluation of the toxicity of the sediments in our freshwater ecosystems. This is somewhat surprising, as these freshwater sediments are subject to the same types of potential contamination as are marine and estuarine sediments. These include:

- industrial discharges,
- shipping and boating related activities,
- municipal and publicly-owned treatment works (POTW) discharges,
- pesticides in agricultural and urban runoff,
- contamination from military base operations,
- acid mine drainage.

The proposed study will investigate to potential for metals contamination from historical mining activities in the upper Sacramento River watershed to adversely affect benthic organiisms and the fish (e.g., salmonids) that feed upon them, and generates the information that will be essential to guiding needed restoration/remediation actions.

**Problem: Historical Mining Activities and Sediment Toxicity and Bioaccumulation of Metals in the Sacramento River Watershed**

Historical mining activities in the Sacramento River watershed have resulted in the introduction of metals into the Sacramento River system. The Central Valley Regional Water Quality Control Board has recently released a TMDL for Cu, Cd, and Zn in the Upper Sacramento River (CVRWQCB 2001) which identifies toxic concentration of dissolved waterborne metals as factors affecting the salmonid populations that use this water body as primary habitat,

However, metals from historical mining activities also accumulate and will continue to accumulate in the Sacramento River sediments. Studies have indicated that mining-related metals contamination of sediments can result in the loss of metals-sensitive species, and reduction in total invertebrate biomass (= less fish food) and number of species (Beltman et al. 1999). Studies of such sediment metals toxicity in the upper Sacramento River are limited to investigation of the toxicity associated with acid-mine drainage depositional piles in Spring Creek and Keswick Reservoir immediately downstream of the Iron Mountain Mine Superfund Site.

Tests have been conducted to assess the potential toxicity that might be associated with the depositional sediment that results from the influx of acid mine drainage into Keswick Reservoir, on the northern Sacramento River (Nordstrom et al. 1999; Finlayson et al. 2000; Ogle et al. 2001). Acute *Ceriodaphnia dubia* toxicity testing of porewaters from several sediment depositional piles indicated extreme toxicity (48 hr LC50s ranging from 0.3 - 1.8% porewater). Chronic toxicity testing of the sediment porewaters with *Ceriodaphnia* indicated substantial reproductive toxicity above and beyond lethal levels (Ogle et al. 2001).

Studies have also indicated that benthic invertebrates collected from the river reach between Keswick Dam and Colusa exhibit elevated tissue concentrations of Cu, Pb, and especially Cd and Zn, which are correlated with the concentrations of these metals in fine-grained sediments, and which exhibit a strong gradient from the upstream metal sources to at least 120 km downstream from the major mine sources (Saiki et al 1995; Cain et al. 1999). Fish which feed upon metals-contaminated invertebrates can be adversely impacted (e.g., significant reductions in growth), and

chronic exposure to the metals is an important factor limiting the distribution and abundance of some fish populations in metals-contaminated watersheds (Besser et al. 2001).

Perhaps a result of the limited information that is available, the recent TMDL for Cu, Cd, and Zn in the upper Sacramento River does not address potential adverse impacts resulting from metals contamination of the river sediments.

Immediate implementation of this proposed study element is particularly critical in terms of potential for remediation/restoration actions to implemented under the framework of soon-to-be-resolved clean-up activities being performed as part of the Iron Mountain Superfund Site Clean-Up Program.

## 2. Justification

### 2a. Conceptual Model

In our conceptual model, metals which enter the aquatic environment, either as dissolved ions or associated with particulate matter, become associated with the sediment through precipitation reactions, adsorption to sediments, adsorption to suspended particulates and subsequent deposition, and accumulation by aquatic organisms and eventual settling of the biomass as detritus.

Depending upon factors that control bioavailability (e.g., grain size, sulfides, etc), these sediment metals can then exert toxic impact to the infaunal benthic organisms, potentially reducing the availability of key food organisms to fish such as salmonids. At sub-lethal concentrations, benthic organisms may survive, but may also may bioaccumulate the sediment metals to levels that can adversely affect consumer organisms such as salmonids. The very limited information that is available suggests that both types of adverse effects may be occurring in the upper Sacramento River, particularly immediately downstream from the iron Mountain Mine (IMM) as well as other mining activities on tributaries to he river.

Verification of such impacts will provide information to fill a critical data gap in the current TMDL effort as well as the ongoing IMM remediation effort. Timely provision of such information may allow remediation of any observed metals-related problems under the funding “umbrella” of the IMM remediation program, providing potentially huge cost savings to CALFED’s restoration plans.

### 2b. Hypotheses of the Proposed Study

The Scope of Work tasks designed to evaluate the problem areas being addressed by the proposed study will test several hypothesis (Note – to minimize the potential for confusion by laypeople stakeholders, these are *not* presented in Null Hypothesis format):

- $H_1$: Metals contamination of upper Sacramento River sediments is causing toxicity to benthic organisms;
- $H_2$: Metals contamination of upper Sacramento River sediments is causing bioaccumulation in benthic organisms to levels that are adversely affecting fish populations, particularly salmonids.

## 3. Proposed Scope of Work

The proposed Scope of Work includes a sampling and testing program to assess the toxicity and boaccumulation of sediment metals in the upper Sacramento River watershed. Sediments will be collected from selected tributaries and main stem river stations. These sediments will be analyzed for toxicity and bioaccumulation using standard EPA totest protocol. Benthic community analyses will also be performed. The sediments and the bioaccumulation test tissues will be analyzed for metals as well as other important physical/chemical characteristics.

As numerous other ongoing and proposed studies are focused on mercury distribution in the watershed, the primary emphasis of this study will be toxicity related to base metals (e.g., Cd, Cu, Ni, Pb, and Zn) however Hg and methyl-Hg will be analyzed in sediments to provide useful information to other studies.

**``Task 1. Identification of Metals "Hot Spots"**

Based upon review of exisiting monitoring data (e.g., Maccoy and Domalgaski 1999; Alpers et al. 2000a,b; ), and in consultation with State and Federal agency scientists, approximately 20 localized areas of sediments with the greatest likelihood of being contaminated with metals will be identified. Sediment samples will be collected from major tributaries to the upper Sacramento River near their confluences with the main-stem between Keswick Dam and Colusa, including Clear Creek, Cottonwood Creek, Elder Creek, Thomes Creek, and Stoney Creek on the western side of the Sacramento Valley, and Battle Creek, Cow Creek, Mill Creek, and Butte Creek on the eastern side of the valley. Sampling stations will also be established at 10 locations along the main-stem Sacramento River, in relation to these tributaries. One goal of this effort will be to assess the relative importance of the Iron Mountain Mines Superfund Site and other mine sites that drain into Lake Shasta as compared with other mine sites and mineralized areas that are drained by tributaries that enter the Sacramento River downstream of Keswick Dam. Initial sediment sampling will be carried out at approximately 30 locations during low-flow conditions in 2002. Follow-up sampling of "hot spots" in selected tributaries and of main-stem sampling sites to define chemical gradients will be done during low-flow conditions during 2003. In the follow-up sampling, both interstitial waters will be also be collected and analyzed for trace metals, including Hg and methylHg.

**Task 2. Collection of Sediment Samples**

Sediment samples will be collected from the selected sampling stations using techniques that are consistent with the Quality Assurance Project Plan (QAPP) of the USGS National Water Quality Assessment Program (NAWQA). Samples will be stored on ice while in the field, and will be logged in and stored at 4˚C within a sample storage refrigerator immediately upon receipt at the laboratory; sediment subsamples for methylHg analysis will be immediately frozen in the field using dry ice and then transferred to a sample storage refrigerator upon receipt at the laboratory. Sediment cores for benthic community analyses will be collected consistent with the California Aquatic Bioassessment Protocol.

**Task 3. Sediment Toxicity Testing**
The sediment samples collected as part of Task 1a will be tested for toxicity using three types of tests:

- 10-day bulk sediment toxicity test with the amphipod *Hyalella azteca* (US EPA 2000);
- 10-day bulk sediment toxicity test with the insect *Chironomus sp.* (US EPA 2000);
- sediment elutriate toxicity test with *Ceriodaphnia dubia* (US EPA 1994).

The bulk sediment tests are deigned to assess toxicity of the surficial sediments to benthic infauna, with two species being tested to provide greater taxonomic representation.

**Task 4. Sediment Bioaccumulation Testing**
The sediment samples collected as part of Task 1a will be tested for metals bioaccumulation potential using the 28-day test with the oligochaete *Lumbriculus variegatus* (US EPA 2000), with the resulting tissues being analyzed for total metals.

**Task 5. Sediment Benthic Community Analyses**
Each sediment sample will be sieved and the collected animals will be placed into a sample jar and preserved in ethanol. The organisms will be later identified to species, when possible, by an aquatic invertebrate taxonomist.

**Task 6. Physical/Chemical Analyses of Sediments and Tissues**
The sediment samples will be analyzed for critical physical and chemical characteristics (e.g., grain size distribution, total organic carbon (TOC), Acid Volatile Sulfides//Simultaneously-Extracted Metals (AVS/SEM), and sediment porewater dissolved metals concentrations), as well as total mercury and methyl mercury. The tissue samples from the bioaccumulation test will be analyzed for trace metals (including Cd, Cu, Fe, Pb, and Zn), total Hg and methylHg. All chemical analyses will be performed by the U.S. Geological Survey or by contract labs approved by the USGS.

A complementary component of this task will be the analysis of the sediment and tissue samples for mercury. While not essential to the successful completion of this task, these mercury analyses will provide, at limited additional cost, valuable information to CALFED and the CVRWQCB on mercury bioaccumulation potential in these sediments.

**Task 7. Report Preparation**
Drs. Ogle and Alpers will prepare appropriate Quarterly and Annual Reports for CALFED.

**PEER REVIEW**
Consistent with the adaptive management policy of CALFED, a Peer Review of the study will be convened immediately after the results of the first year of study are available. It is expected that this per review panel will consist primarily of representatives from stakeholder agencies that have involvement at some level in the issue of metals in the upper Sacramento River (US EPA Region 9, CVRWQCB, US Fish and Wildlife Service), along with CALFED representatives and any other identified interested stakeholders.

The Peer Review Panel will review and evaluate the results of the first year of the study, and will provide guidance towards the final design and implementation of Year 2 of the study.

**YEAR 2 Scope of Work**

The Scope of Work for the second year of the proposed study will tentatively consist of determining the spatial extent of toxicity problems at locations where significant toxicity and/or bioaccumulation is observed based upon sampling and analysis during Year 1. It is expected that the 5 stations from the first year of study that exhibit the greatest degree of metals toxicity and or bioaccumulation will be targeted as "hot spots" and that more detailed sampling in areas both upstream and downstream of these areas will be carried out during Year 2. It is anticipated that these 5 "hot spot" stations will be resampled to confirm the first year's results, and that about 5 additional stations will be established in the vicinity of each of these 5 "hot spots", for a total of 30 stations to be sampled during Year 2. Sediments sampled during Year 2 will be tested and analyzed in a manner consistent with the Year 1 study tasks.

**Preparation of Deliverables**

Drs. Ogle and Alpers will prepare appropriate Quarterly and Annual Reports for CALFED, prepare scientific presentation(s) describing this work for presentation at relevant Regional- and National-Level scientific conferences, and prepare manuscripts for peer-reviewed publication in technical/scientific journals.

A final report describing results from 2002 and 2003 samples will be prepared for peer review during 2004 and will be completed by September 2005.

## 4. Feasibility of the Proposed Study

The proposed Scope of Work is extremely feasible, and the sampling and biological testing are services performed by PER on a routine basis. The PER scientists have performed hundreds-to-thousands of solid-phase, liquid/suspended-phase (= elutriate), sediment porewater, intact sediment core ("sediment-water interface"), and water column toxicity studies using a wide variety of freshwater, estuarine, and marine species. These tests have been performed for various agencies and applications, including ambient monitoring, ecological risk assessment, site remediation clean-up goals, wetlands restoration projects, as well as dredge materials evaluations. Agencies reviewing the biological testing performed by PER staff include, but are not limited to, US EPA, US Army Corps of Engineers, US Fish & Wildlife Service, San Francisco Bay and Central Valley (and other) Regional Water Quality Control Board(s), CA Department of Toxic Substances Control, CA Department of Fish and Game, and the Bay Conservation and Development Commission. PER is certified for the performance of toxicity testing by the State of California's Environmental Laboratory Accreditation Program. This certification is based upon a critical review of the Laboratory's QA/QC Plan (including all relevant Standard Operating Procedures) and an extensive site audit of the testing laboratory.

As part of maintaining their status as the premiere biological testing lab on the West Coast, PER has just recently completed moving into new facilities which include two laboratories: Testing Lab

#1 consists of 1800 square feet of testing and analytical capability dedicated to both aquatic and sediment toxicity testing; Testing Lab #2 consists of 1800 square feet of testing capability dedicated strictly to sediment toxicity and bioaccumulation testing. These laboratories are state-of-the-art, and include the full complement of supplies and equipment needed for the proposed study.

Dr. Ogle and the PER team are also very capable of managing the proposed Scope of Work. Dr. Ogle has been the PI in managing the aquatic toxicity testing component of the San Francisco Estuary RMP for the past several years, and has just been selected to continue in this capacity for the next five year arc of the program. Dr. Ogle and Mr. Clark were recently selected to manage the ambient water monitoring for the Sacramento River Watershed Program (SRWP), which includes logistical planning of "clean technique" field sampling, toxicity testing, and toxicity identification evaluations (TIEs). Management of several sub-contracting analytical and testing firms has been an integral component of the SRWP, and all work on that project has been performed with implementation and monitoring of QA measures and compliance with the QAPP for all project activities. Performance to date by PER in managing this project has been characterized as "Superlative". PER was also recently selected to help manage the Bay-wide Site-Specific Copper Water Effects Ratio Study, which also included logistical planning and performance of "clean technique" field sampling, toxicity testing , and management of several sub-contracting analytical labs. This type and level of project management is typical of most of the non-NPDES-related projects performed by Dr. Ogle and the PER team of scientists.

**5. Performance Measures for the Proposed Study**

A schedule for the performance and completion of Tasks for the Proposed Scope of Work is provided in Section 8, below, and can be used by CALFED staff and reviewers to track project performance.

**6. Data Handing and Storage**

Pacific EcoRisk will be responsible for data management and storage procedures for all toxicity and bioaccumulation testing data. Testing and analytical results data will be recorded in Microsoft Excel spreadsheets under the supervision of the Principal Investigator, and compiled into an Oracle database, which will be maintained by Pacific EcoRisk. All data will be reviewed for compliance with established QA requirements. The final database will be made available on Pacific EcoRisk's web site (currently being completed) and will be available for both inspection and retrieval. The U.S. Geological Survey will be responsible for data management and storage for all sediment chemistry data. The preliminary data will be stored in Microsoft Excel spreadsheets under the supervision of the Co-Investigator. The sampling sites will be established as official USGS stations, and the final data will be stored in the USGS's National Water Information System (NWIS), which is now accessible on the internet (NWISWEB - http://ut.water.usgs.gov/nwis.htm>).

**7. Expected Products**

A Year 1 Field Sampling Report and Year 1 Annual Report will be prepared as per the schedule below. Subsequent to the Year 1 Peer Review, a Year 2 Field Sampling Report as per the schedule, and an overall Project Final Report will be submitted to CalFed once all data are available and have been reviewed. In addition, it is expected that this work will support technical publications in peer-

reviewed scientific journals. Project proponents will further disseminate the acquired information in oral presentations at Cal Fed symposia and related scientific meetings (e.g., the forthcoming CalFed Science Conference in 2002, State-of-the-Estuary Conference, etc.).

## 8. Work Schedule

Table 1. Task schedule and milestones

| Study Task | Year 1 | | | | Year 2 | | | | Year 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Quarters) | | | | (Quarters) | | | | (Quarters) | | | |
| YEAR 1 TASKS | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Task 1. Identification of Metals "Hot Spots" | X | | | | | | | | | | | |
| Task 2. Site Reconnaissance | X | | | | | | | | | | | |
| Task 3. Collection of Sediment Samples | X | X | | | | | | | | | | |
| Task 4. Sediment Toxicity Testing | | X | | | | | | | | | | |
| Task 5. Sediment Bioaccumulation Testing | | X | X | | | | | | | | | |
| Task 6. Sediment Benthic Community Analyses | | X | | | | | | | | | | |
| Task 7. Chemical Analyses of Sediments & Tissues | | X | X | | | | | | | | | |
| Preparation of Year 1 Field Sampling Report | | X | | | | | | | | | | |
| Preparation of Year 1 Annual Report | | | | X | | | | | | | | |
| Year 1 Peer Review | | | | X | | | | | | | | |
| | | | | | | | | | | | | |
| YEAR 2 TASKS | | | | | | | | | | | | |
| Task 2. Site Reconnaissance | | | | | X | | | | | | | |
| Task 3. Collection of Sediment Samples | | | | | X | | | | | | | |
| Task 4. Sediment Toxicity Testing | | | | | | X | | | | | | |
| Task 5. Sediment Bioaccumulation Testing | | | | | | X | X | | | | | |
| Task 6. Sediment Benthic Community Analyses | | | | | | X | | | | | | |
| Task 7. Chemical Analyses of Sediments & Tissues | | | | | | X | X | | | | | |
| Preparation of Year 2 Field Sampling Report | | | | | | X | | | | | | |
| Preparation of Year 2 Annual Report | | | | | | | | X | | | | |
| Year 2 Peer Review | | | | | | | | X | | | | |
| | | | | | | | | | | | | |
| YEAR 3 TASKS | | | | | | | | | | | | |
| Preparation of Draft Final Report | | | | | | | | | X | X | | |
| Peer Review of Draft Final Report | | | | | | | | | | X | | |
| Preparation and Publication of Final Report | | | | | | | | | | | X | |

## 9. Applicability to CALFED ERP and Science Goals

### 9a. Relation of Proposed Study to ERP, Science Program and CVPIA Priorities

Strategic Goal 1 – At Risk Species and …
Strategic Goal 3 – Harvestable Species: The proposed project investigates the potential impacts that metals in the upper Sacramento River sediments may have on important salmonid species. The sediment toxicity tests in the proposed study assess potential adverse impacts on the benthic

organisms that serve as key food items for salmonid. In addition, the bioaccumulation tests in the proposed study assess the potential for adverse impact on the salmonids and other fish that consume these food organisms.

Strategic Goal 4 – Habitats: The chemical characteristics of a given aquatic system can be an important feature of the habitat, particularly when chemical contaminants impair the ability of aquatic organisms too survive, grow, and reproduce. The proposed study assesses the suitability of selected areas in the upper Sacramento River to serve as "successful" habitat for critical salmonid populations, including areas currently being considered for remediation under the IMM clean-up program.

Strategic Goal 6 – Sediment and Water Quality: The goal "to improve and maintain water and sediment quality… and eliminate, to the extent possible, toxic impacts on organisms in the system, including humans" is the major focus of this project.

**9b. Relation of Proposed Study to Other Ecosystem Restoration Projects**

The proposed project will provide information of importance to other ongoing CALFED ERP-funded projects: 1) monitoring of contaminant effects on rainbow trout (ERP-01-N22).

**9c. Request for Next-Phase Funding**

*Not Applicable.*

**9d. Previous Recipient**

One of the principal investigators, Dr. Charles Alpers, are both currently associated with the CALFED Directed Action Project on Mercury entitled: "Assessment of Ecological and Human Health Impacts of Mercury in the Bay-Delta Watershed". The mid-year progress report and review of an independent scientific review panel for that project is available on the Internet at <http://loer.tamug.tamu.edu/calfed/Reports.htm>.

Dr. Alpers is also involved with the Upper Yuba River Studies Program (UYRSP), a project that is funded under CALFED's Ecosystem Restoration Program. Dr. Alpers is the Project Chief for the USGS part of the project (Water Quality and Sediment Studies) and serves as coordinator for the Technical Review Panel for the UYRSP.

**9e. System-Wide Ecosystem Benefits**

As per its mission, CALFED has committed considerable resources to the improvement and restoration of fish resources within the Sacramento-San Joaquin Delta watersheds. Unfortunately, some fish populations may be adversely impacted by contaminants, inhibiting planned restoration efforts. Sediment metals toxicity to, and bioaccumulation in important fish food organisms in the upper Sacramento River may be adversely impacting important salmonid populations. It is essential that the toxicity and bioaccumulation problems of metals-contaminated sediments be controlled in order to achieve the full benefits of CALFED's ecosystem restoration program.

**9f. Land Acquisition Information**

*Not applicable.*

**10. Qualifications**

**Dr. R. Scott Ogle, Pacific EcoRisk**

For almost 17 years, Dr. Scott Ogle has been directing and/or participating in research in the areas of aquatic ecotoxicology and environmental chemistry. Dr. Ogle's major area of research includes evaluation of the fate and effects of metals, pesticides, and petroleum and petroleum products in aquatic ecosystems and the investigation of contaminants and toxicity in non-point source and stormwater runoff. Dr. Ogle has directed and participated in numerous projects encompassing all of the standardized EPA and ASTM test procedures as well as projects involving development of new testing procedures.

Much of Dr. Ogle's recent work has focused upon evaluation of contaminated freshwater, estuarine, and marine sediments, and he and his lab staff have rapidly established a reputation as being one of the best sediment and aquatic testing lab in California. Dr. Ogle's sediment investigations incorporate the latest developments in study design, sample collection, toxicity and bioaccumulation testing, and interpretation of data. These sediment evaluations also incorporate the latest regulatory recommendations and are consistent with established guidelines.

After recent competitive evaluations, Dr. Ogle's research team have been selected over other Bay area and West Coast firms to perform sediments sampling and testing services for the Moss Landing Harbor District, the City and County of San Francisco, the Port of Oakland, and the U.S. Army Corps of Engineers. After similar competitive evaluations (including on-site lab audits), Dr. Ogle's team has also been selected to provide sediment toxicity and bioaccumulation testing for most of the military base re-alignment and closure projects, including the Presidio, the Concord Naval Weapons Facility, the Alameda Naval Air Station, the Pt. Molate Naval Fuel Depot, the Oakland Army Base, McClellan Air Force Base, the US Navy Hunter's Point Annex, as well as the Mare Island Naval Shipyard. PER has also provided similar services as part of ongoing Bay Protection and Toxic Cleanup Program evaluations for Zeneca Ag Products, as well as the City & County of San Francisco. Performance of all of these projects has involved a direct management role by Dr. Ogle, from conception and design of experimental approach, through completion of studies and analyses of results, and finally, reporting of the results to the concerned parties.

**Dr. Charles N. Alpers**

Dr. Alpers received a Ph.D. in geochemistry from the University of California, Berkeley in 1986. He has been involved in numerous water-quality investigations involving trace-element geochemistry and the transport of trace elements in surface- and ground water systems. Dr. Alpers has conducted research concerning acid mine drainage at the Iron Mountain Mines Superfund site, in cooperation with the EPA, since joining the USGS as a post-doctoral fellow in 1987. Since joining the USGS California District Office in 1991, Dr. Alpers has been Project Chief for several projects, including the characterization of ground water affected by acid mine drainage at Penn Mine, in cooperation with State Water Resources Control Board and the East Bay Municipal Utility District. Dr. Alpers recently completed his role as Project Chief of the Sacramento River Trace Metals Transport Project, characterizing the geochemistry of trace elements, including mercury, in the Sacramento River along a reach of the river between Shasta Dam and Freeport, in cooperation with the State Water Resources Control Board, the Sacramento County Regional Sanitation District,

the US EPA, and the National Marine Fisheries Service. Dr. Alpers is a member of several technical advisory committees involved with the remediation of inactive and abandoned mine sites in California and other states, and has published extensively on the topics of the environmental geochemistry of sulfide oxidation, ground-water characterization at mine sites, and the effects of efflorescent salts on mine drainage composition. Dr. Alpers is currently the Project Chief of an interagency project that is addressing mercury contamination from historic gold mining in the Yuba River and Bear River watersheds, and he also is serving as task co-leader (with Dr. Joseph Domagalski) and quality assurance/quality control officer for the USGS portion of the CalFed project "Assessment of the effects of mercury contamination on human health and ecosystems in the Bay-Delta." In addition, Dr. Alpers is the Project Chief for the USGS portion (Water Quality and Sediment Studies scopes of work) of CalFed's Upper Yuba River Studies Program, and serves as coordinator of the external Technical Review Panel for that program.

## 11. Proposed Study Budget

| | Pacific EcoRisk | U.S. Geological Survey |
|---|---|---|
| **Total YEAR 1 Costs** | **$ 267,230** | **$ 94,144** |
| **Total YEAR 2 Costs** | **$ 250,879** | **$ 147,764** |
| **Total YEAR 3 Costs** | **$ 26,040** | **$ 43,454** |
| **TOTAL PROJECT COSTS =** | **$ 544,149** | **$ 285,362** |

**OVERALL TOTAL PROJECT COSTS = $ 829,511**

See appendices for Budget details.

## 12. Literature Cited


Alpers CN, Taylor HE, Domagalski JL (2000) Metals transport in the Sacramento River, California, 1996-1997. Volume 1: Methods and Data. U.S. Geological Survey Water Resources Investigations Report 99-4286.

Alpers CN, Antweiler RC, Taylor HE, Dileanis PD, Domagalski JL (2000) Metals transport in the Sacramento River, California, 1996-1997. Volume 2: Interpretation of Metals Loads. U.S. Geological Survey Water Resources Investigations Report 00-4002.

Beltman DJ, Clements WH, Lipton J, Cacela D (1999) Benthic invertebrate metals exposure, accumulation, and community-level effects downstream from a hard-rock mine site. Environ Toxicol Chem 18(2):299-307.

Besser JM, Brumbaugh WG, May TW, Church SE, Kimball BA (2001) Bioavailability of metals in stream food webs and hazards to brook trout (*Salvelinus fontinalis*) in the Upper Animas River watershed, Colorado. Arch Environ Contam Toxicol 40:48-59.

Cain DJ, Carter J, Fend S, Luoma SN, Alpers CN, Taylor HE (2000) Metal exposure to a benthic macroinvertebrate, *Hydropsyche californica*, related to mine drainage in the Sacramento River. Canad J Fish Aquat Sci 57:380-390.

Daniels RA, Moyle PB (1983) Life history of splittail (Cyprinidae: *Pogonichthys macrolepidotus*) in the Sacramento-San Joaquin Estuary. Fish Bull 81:647-654.

Davis JA, Gunther AJ, Richardson BJ, O'Connor JM, Spies RB, Wyatt E, Larson E, Meiorin EC (1991) Status and Trends Report on Pollutants in the San Francisco Estuary. San Francisco Estuary Institute, Oakland, CA.

Feyrer F, Matern SA (2000) Changes in fish diets in the San Francisco Estuary following the invasion of the clam *Potamocorbula amurensis*. IEP Newsletter 13(4):21-27.

Finlayson B, Fujimura R, Huang ZZ (2000) Toxicity of metal-contaminated sediments from Keswick Reservoir, California, USA. Environ Toxicol Chem 19(2):485-494.

Maccoy, DE, and Domagalski, JL (1999) Trace elements and organic compounds in streambed sediments and aquatic biota from the Sacramento River Basin, California, October and November 1995. U.S. Geological Survey Water-Resources Investigations Report 99-4151, 37 p.

Mann KH (1980) Benthic secondary production. Pages 103-118 in: Barnes RSK, Mann KH (eds) *Fundamentals of Aquatic Ecosystems*. Blackwell Scientific Publications, London, UK.

Monroe MW, Kely J, Lisowski N (1992) State of the Estuary: A report on the conditions and problems in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. San Francisco Estuary Project, Oakland, CA.

Nordstrom DK, Alpers CN, Coston JA, Taylor HE, McCleskey RB, Ball JW, Ogle S, Cotsifas JS, Davis JA. (1999) Geochemistry, toxicity, and sorption properties of contaminated sediments and pore waters from two reservoirs receiving acid mine drainage. U.S. Geological Survey Water-Resources Investigations Report 99-4018A.

Novartis (1997) An Ecological Risk Assessment of Diazinon in the Sacramento and San Joaquin River Basins. Technical Report: 11/97, Novartis Crop Protection, Inc., Greensboro, NC.

Ogle RS, Cotsifas JS, Alpers CN, Nordstrom DK (2001) Evaluation of ther toxicity of Acid Mine Drainage depositional sediments at the Iron Mountain Mines SuperFund Site..Manuscript in preparation.

Roth, DA, Taylor, HE, Domagalski, J, Dileanis, P, Peart, DB, Antweiler, RC, Alpers, CN (2001) Distribution of inorganic mercury in Sacramento River water and suspended colloidal sediment material: Archives of Environmental Toxicology 40:161-172.

Saiki MK, Schmitt CJ (1985) Population biology of bluegills, *Lepomis macrochirus*, in lotic habitats on the irrigated San Joaquin Valley floor. Calif Fish Game 71(4):225-244.

Saiki MK, Castleberry DT, May TW, Martin BA, Bullard FN (1995) Copper, cadmium, and zinc concentrations in aquatic food chains from the Upper Sacramento River (California) and selected tributaries. Arch Environ Contam Toxicol 29:484-491.

Schaffter RG, Jones PA, Karlton JG (1982) Sacramento River and tributaries bank protection and erosion control investigation: Evaluation of impacts on fisheries. Final Report, CA Dept. Fish & Game/US Army Corps of Engineers Contract No. DACWO 5-80-C-0110.

Sommer T, Nobriga M, Harrell B, Batham W, Kurth R, Kimmerer W (2000) Floodplain rearing may enhance growth and survival of juvenile chinook salmon in the Sacramento River. IEP Newsletter 13(3):21-30.

Vannote RI, Minshall GW, Cummins KW, Sedell JR, Cushing CE (1980) The River Continuum Concept. Canad J Fish Aquat Sci 37:130-137.

Vogel DA, Marine KR (1991) Guide to Upper Sacramento River chinook salmon life history. Prepared for the US Bureau of Reclamation, Central Valley Project, July 1991.

US EPA (1994) Short-term methods for estimating the chronic toxicity of effluents and receiving waters to freshwater organisms, Third Edition. EPA/600/4-91/002. U.S. EPA, Environmental Monitoring Systems Laboratory, Cincinnati, OH.

US EPA (2000) Methods for measuring the toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates. EPA/600/R-99/064. U.S. EPA, Washington, D.C.

## APPENDIX A: BUDGET DETAIL FOR PACIFIC ECORISK

### YEAR 1 (Pacific EcoRisk)

**Task 1. Identification of Sampling Stations**

| | | |
|---|---|---|
| Dr. Scott Ogle | 120 hrs @ $125/hr | $ 15,000 |
| Stephen Clark | 40 hrs @ $85/hr | $ 3,400 |
| Technician (for Library copies) | 80 hrs @ $40/hr | $ 3,200 |
| Photocopies | | $ 500 |
| | **Task 1 Sub-Total** | **$ 22,100** |

**Task 2. Site Reconnaissance**

| | | |
|---|---|---|
| Stephen Clark | 2 days @ 10 hrs/day @ $85/hr | $ 1,700 |
| Staff Scientist I | 2 days @ 10 hrs/day @ $65/hr | $ 1,300 |
| Travel | 2,000 miles + Lodging and Meals | $ 1,000 |
| | **Task 2 Sub-Total** | **$ 4,000** |

**Task 3. Collection of Samples**

| | | |
|---|---|---|
| Staff Scientist I | 5 days @ 10 hrs/day @ $65/hr | $ 3,250 |
| Staff Scientist II | 5 days @ 10 hrs/day @ $55/hr | $ 2,750 |
| Staff Scientist II | 8 hrs @ $55/hr | $ 440 |
| Technician | 8 hrs @ $40/hr | $ 320 |
| Truck Rental | 5 days @ $100/day | $ 500 |
| Boat Rental | 5 days @ $650/day | $ 3,250 |
| Supplies (site water collection tanks | | $ 5,000 |
| Travel (2000 miles + Lodging and Meals) | | $ 2,000 |
| | **Task 3 Sub-Total** | **$ 17,510** |

**Task 4. Sediment Toxicity Testing**

| | | |
|---|---|---|
| Bulk Sediment Toxicity Testing with *Hyalella azteca* | | |
| 30 tests @ $850/test | | $ 25,500 |
| Bulk Sediment Toxicity Testing with *Chironomus tentans* | | |
| 30 tests @ $900/test | | $ 27,000 |
| Sediment Elutriate Toxicity Testing with *Ceriodaphnia dubia* | | |
| 30 tests @ $650/test | | $ 19,500 |
| Preparation of Sediment Elutriate | | |
| Staff Scientist I | 30 hrs @ $65/hr | $ 1,950 |
| | **Task 4 Sub-Total** | **$ 73,950** |

**Task 5. Sediment Bioaccumulation Testing**

| | | |
|---|---|---|
| 28-day Sediment Bioaccumulation Testing with *Lumbriculus variegatus* | | |
| 30 tests @ $1,800/test | | $ 54,000 |
| | **Task 5 Sub-Total** | **$ 54,000** |

**Task 6. Sediment Benthic Community Analyses**

| | | |
|---|---|---|
| Sediment Benthic Community Analyses | | |
| 30 samples @ $900/sample | | $ 27,000 |
| | **Task 6 Sub-Total** | **$ 27,000** |

**Task 7a. Chemical Analyses of Sediment Samples**

Sediment Analyses Performed by US Geological Survey

**Task 7b. Chemical Analyses of Tissue Samples**

Tissue Chemistry Contracted to Battelle $ 20,950

**Task 8. Report Preparation**

| | | |
|---|---|---|
| Dr. Scott Ogle | 160 hrs @ $125/hr | $ 20,000 |
| Stephen Clark | 40 hrs @ $85/hr | $ 3,400 |
| | **Task 8 Sub-Total** | **$ 44,350** |

**Project Management Pacific EcoRisk**

| | | |
|---|---|---|
| Supervision of Sediment Sampling and Testing | | |
| Dr. Scott Ogle | 80 hrs @ $125/hr | $ 10,000 |
| Stephen Clark | 40 hrs @ $85/hr | $ 3,400 |
| Attendance/Presentation at Scientific Conference (1 Local + 1 National) | | |
| Dr. Scott Ogle | 24 hrs @ $125/hr | $ 3,000 |
| Stephen Clark | 24 hrs @ $85/hr | $ 2,040 |
| Travel | | $ 4,000 |
| Peer Review Meeting | | |
| Dr. Scott Ogle | 8 hrs @ $125/hr | $ 1,000 |
| Stephen Clark | 8 hrs @ $85/hr | $ 680 |
| Travel | | $ 200 |
| | **Project Management Sub-Total** | **$ 24,320** |
| | **TOTAL YEAR 1 COSTS** | **$ 267,230** |

**YEAR 2 BUDGET (Pacific EcoRisk)**

**Task 1.** **Not Applicable**

**Task 2. Site Reconnaissance**

| | | |
|---|---|---|
| Stephen Clark | 2 days @ 10 hrs/day @ $90/hr | $ 1,800 |
| Staff Scientist I | 2 days @ 10 hrs/day @ $69/hr | $ 1,380 |
| Travel | 2,000 miles + Lodging and Meals | $ 1,050 |
| | **Task 2 Sub-Total** | **$ 4,230** |

**Task 3. Collection of Samples**

| | | |
|---|---|---|
| Staff Scientist I | 5 days @ 10 hrs/day @ $69/hr | $ 3,450 |
| Staff Scientist II | 5 days @ 10 hrs/day @ $58/hr | $ 2,900 |
| Staff Scientist II | 8 hrs @ $58/hr | $ 464 |
| Technician | 8 hrs @ $42/hr | $ 336 |
| Truck Rental | 5 days @ $105/day | $ 525 |
| Boat Rental | 5 days @ $690/day | $ 3,450 |
| Supplies | | $ 5,250 |
| Travel (2000 miles + Lodging and Meals) | | $ 2,100 |
| | **Task 3 Sub-Total** | **$ 18,475** |

**Task 4. Sediment Toxicity Testing**

| | | |
|---|---|---|
| Bulk Sediment Toxicity Testing with *Hyalella azteca* | | |
| 30 tests @ $900/test | | $ 27,000 |
| Bulk Sediment Toxicity Testing with *Chironomus tentans* | | |
| 30 tests @ $950/test | | $ 28,500 |
| Sediment Elutriate Toxicity Testing with *Ceriodaphnia dubia* | | |
| 30 tests @ $700/test | | $ 21,000 |
| Preparation of Sediment Elutriate | | |
| Staff Scientist 1 | 30 hrs @ $69/hr | $ 2,070 |
| | **Task 4 Sub-Total** | **$ 78,570** |

**Task 5. Sediment Bioaccumulation Testing**

| | | |
|---|---|---|
| 28-day Sediment Bioaccumulation Testing with *Lumbriculus variegatus* | | |
| 30 tests @ $1,900/test | | $ 57,000 |
| | **Task 5 Sub-Total** | **$ 57,000** |

**Task 6. Sediment Benthic Community Analyses**

| | | |
|---|---|---|
| Sediment Benthic Community Analyses | | |
| 30 samples @ $950/sample | | $ 28,500 |
| | **Task 6 Sub-Total** | **$ 28,500** |

***Task 7. Chemical Analyses of Sediment and Tissue Samples***

| | | |
|---|---|---|
| Tissue Chemistry | | $ 22,000 |

**Task 8. Report Preparation**

| | | |
|---|---|---|
| Dr. Scott Ogle | 160 hrs @ $132/hr | $ 21,120 |
| Stephen Clark | 40 hrs @ $90/hr | $ 3,600 |
| | **Task 8 Sub-Total** | **$ 46,720** |

**Project Management Pacic EcoRisk**

| | | |
|---|---|---|
| Supervision of Sediment Sampling and Testing | | |
| Dr. Scott Ogle | 80 hrs @ $132/hr | $ 10,560 |
| Stephen Clark | 40 hrs @ $90/hr | $ 3,600 |
| Attendance/Presentation at Scientific Conference (1 Local + 1 National) | | |
| Dr. Scott Ogle | 24 hrs @ $132/hr | $ 3,168 |
| Travel | | $ 2,100 |
| Peer Review Meeting | | |
| Dr. Scott Ogle | 8 hrs @ $132/hr | $ 1,056 |
| Stephen Clark | 8 hrs @ $90/hr | $ 720 |
| Travel | | $ 210 |
| | **Project Management Sub-Total** | **$ 21,414** |
| | **TOTAL YEAR 2 COSTS** | **$ 250,879** |

**YEAR 3 BUDGET (Pacific EcoRisk)**

**Task 1-7** **Not Applicable**

**Task 8. Report Preparation**

| | | |
|---|---|---|
| Dr. Scott Ogle | 160 hrs @ $139/hr | $ 22,240 |
| Stephen Clark | 40 hrs @ $95/hr | $ 3,800 |
| | **Task 8 Sub-Total** | **$ 26,040** |
| | **TOTAL YEAR 3 COSTS** | **$ 26,040** |
| | **TOTAL PROJECT COSTS =** | **$ 544,149** |

## Appendix B: Budget Detail for US Geological Survey

### YEAR 1 BUDGET (US Geological Survey)

**Task 1. Identification of Sampling Stations**

| | | |
|---|---|---|
| Dr. Charlie Alpers | 40 hrs @ $61.60/hr | $ 2,464 |
| Dr. Joe Domalgaski | 10 hrs @ $55.40/hr | $ 554 |
| M. Hunerlach, Geologist | 20 hrs @ $33.70/hr | $ 674 |
| Supplies | | $ 200 |
| US Geological Survey Overhead | | $ 3,721 |
| | **Task 1 Sub-Total** | **$ 7,613** |

**Task 2. Site Reconnaissance**

| | | |
|---|---|---|
| M. Hunerlach, Geologist | 20 hrs @ $33.70/hr | $ 674 |
| M. Johnson, Technician | 20 hrs @ $31.35/hr | $ 627 |
| S. Gallanthine, Hydrologist | 20 hrs @ $28.90/hr | $ 578 |
| C. Clapton, Hydrologist | 20 hrs @ $13.55/hr | $ 271 |
| Travel | | $ 200 |
| Other (vehicles, communications) | | $ 400 |
| US Geological Survey Overhead | | $ 2,629 |
| | **Task 2 Sub-Total** | **$ 5,379** |

**Task 3. Collection of Samples**

| | | |
|---|---|---|
| Dr. Charlie Alpers | 20 hrs @ $61.60/hr | $ 1,232 |
| M. Hunerlach, Geologist | 20 hrs @ $33.70/hr | $ 674 |
| M. Johnson, Technician | 100 hrs @ $31.35/hr | $ 3,135 |
| S. Gallanthine, Hydrologist | 40 hrs @ $28.90/hr | $ 1,156 |
| C. Clapton, Hydrologist | 100 hrs @ $13.55/hr | $ 1,355 |
| Equipment | | $ 300 |
| Supplies | | $ 1,000 |
| Travel | | $ 800 |
| Other (vehicles, communications, shipping) | | $ 1,300 |
| US Geological Survey Overhead | | $ 10,471 |
| | **Task 3 Sub-Total** | **$ 21,423** |

**Task 4. Sediment Toxicity Testing** — **Not Applicable**

**Task 5. Sediment Bioaccumulation Testing** — **Not Applicable**

**Task 6. Sediment Benthic Community Analyses** — **Not Applicable**

**Task 7a. Chemical Analyses of Sediment Samples**

| | | |
|---|---|---|
| Dr. Charlie Alpers | 20 hrs @ $61.60/hr | $ 1,232 |
| S. Dudash, Computer Ass't | 20 hrs @ $15/hr | $ 300 |
| Services (Chemical Analyses) | | $ 19,500 |
| Other (communications) | | $ 100 |
| US Geological Survey Overhead | | $ 20,200 |
| | **Task 7a Sub-Total** | **$ 41,332** |

**Task 7b. Chemical Analyses of Tissue Samples** **Not Applicable**

**Task 8. Report Preparation**

| | | |
|---|---|---|
| Dr. Charlie Alpers | 60 hrs @ $61.60/hr | $ 3,696 |
| Dr. Joe Domalgaski | 30 hrs @ $55.40/hr | $ 1,662 |
| S. Dudash, Computer Ass't | 20 hrs @ $15/hr | $ 300 |
| US Geological Survey Overhead | | $ 5,410 |
| | **Task 8 Sub-Total** | **$ 11,068** |

**Project Management Pacific EcoRisk**

| | | |
|---|---|---|
| Dr. Charlie Alpers | 60 hrs @ $61.60/hr | $ 3,696 |
| Other (communications) | | $ 100 |
| US Geological Survey Overhead | | $ 3,533 |
| | **Project Management Sub-Total** | **$ 7,329** |
| | **TOTAL YEAR 1 COSTS** | **$ 94,144** |

**YEAR 2 BUDGET (US Geological Survey)**

**Task 1.** **Not Applicable**

**Task 2. Site Reconnaissance**

| | | |
|---|---|---|
| M. Hunerlach, Geologist | 20 hrs @ $35.40/hr | $ 708 |
| M. Johnson, Technician | 20 hrs @ $32.90/hr | $ 658 |
| S. Gallanthine, Hydrologist | 20 hrs @ $30.35/hr | $ 607 |
| C. Clapton, Hydrologist | 20 hrs @ $14.30/hr | $ 286 |
| Travel | | $ 200 |
| Other (vehicles, communications) | | $ 400 |
| US Geological Survey Overhead | | $ 2,648 |
| | **Task 2 Sub-Total** | **$ 5,507** |

**Task 3. Collection of Samples**

| | | |
|---|---|---|
| Dr. Charlie Alpers | 40 hrs @ $64.70/hr | $ 2,588 |
| M. Hunerlach, Geologist | 80 hrs @ $35.40/hr | $ 2,832 |
| M. Johnson, Technician | 160 hrs @ $32.90/hr | $ 5,264 |
| S. Gallanthine, Hydrologist | 80 hrs @ $30.35/hr | $ 2,428 |
| C. Clapton, Hydrologist | 160 hrs @ $14.30/hr | $ 2,288 |
| Equipment | | $ 300 |
| Supplies | | $ 1,000 |
| Travel | | $ 800 |
| Other (vehicles, communications, shipping) | | $ 1,300 |
| US Geological Survey Overhead | | $ 17,417 |
| | **Task 3 Sub-Total** | **$ 36,217** |

**Task 4. Sediment Toxicity Testing** **Not Applicable**

**Task 5. Sediment Bioaccumulation Testing** **Not Applicable**

**Task 6. Sediment Benthic Community Analyses** **Not Applicable**

**Task 7a. Chemical Analyses of Sediment Samples**

| | | |
|---|---|---|
| Dr. Charlie Alpers | 20 hrs @ $64.70/hr | $ 1,294 |
| S. Dudash, Computer Ass't | 20 hrs @ $16/hr | $ 320 |
| Services (Chemical Analyses) | | $ 39,000 |
| Other (communications) | | $ 100 |
| US Geological Survey Overhead | | $ 37,733 |
| | **Task 7a Sub-Total** | **$ 78,447** |

**Task 7b. Chemical Analyses of Tissue Samples** **Not Applicable**

**Task 8. Report Preparation**

| | | |
|---|---|---|
| Dr. Charlie Alpers | 120 hrs @ $64.70/hr | $ 7,764 |
| Dr. Joe Domalgaski | 40 hrs @ $58.25/hr | $ 2,330 |
| S. Dudash, Computer Ass't | 20 hrs @ $16/hr | $ 320 |
| US Geological Survey Overhead | | $ 9,649 |
| | **Task 8 Sub-Total** | **$ 20,063** |

**Project Management**

| | | |
|---|---|---|
| Dr. Charlie Alpers | 60 hrs @ $64.70/hr | $ 3,882 |
| Other (communications) | | $ 100 |
| US Geological Survey Overhead | | $ 3,548 |
| | **Project Management Sub-Total** | **$ 7,530** |
| | **TOTAL YEAR 2 COSTS** | **$ 147,764** |

**YEAR 3 BUDGET (US Geological Survey)**

**Task 1-7** **Not Applicable**

**Task 8. Report Preparation**

| | | |
|---|---|---|
| Dr. Charlie Alpers | 140 hrs @ $64.70/hr | $ 9,058 |
| Dr. Joe Domalgaski | 40 hrs @ $58.25/hr | $ 2,330 |
| S. Dudash, Computer Ass't | 20 hrs @ $16/hr | $ 320 |
| Travel | | $ 600 |
| Supplies | | $ 500 |
| Other (vehicles, shipping, printing) | | $ 1 900 |
| US Geological Survey Overhead | | $ 16,532 |
| | **Task 8 Sub-Total** | **$ 31,240** |

**Project Management**

| | | |
|---|---|---|
| Dr. Charlie Alpers | 80 hrs @ $64.70/hr | $ 5,176 |
| Travel | | $ 1,200 |
| Other (communications) | | $ 100 |
| US Geological Survey Overhead | | $ 5,738 |
| | **Project Management Sub-Total** | **$ 12,214** |
| | **TOTAL YEAR 3 COSTS** | **$ 43,454** |
| | **TOTAL PROJECT COSTS =** | **$ 285,362** |

# Appendix C: RICHARD SCOTT OGLE, Ph.D.
## Lab Director, Pacific Eco-Risk Laboratories

For over ten years, Dr. Scott Ogle has been directing and/or participating in research in the areas of aquatic ecotoxicology and environmental chemistry. A major area of Dr. Ogle's past research efforts has focused on factors affecting toxicity and bioaccumulation of selenium to algae, invertebrates, and fish and have established him as an expert in this field. Current research activities include evaluation of the fate and effects of metals, pesticides, and petroleum and petroleum products in the aquatic environment and the investigation of contaminants and toxicity in non-point source and stormwater runoff. Dr. Ogle has directed and participated in numerous projects encompassing all of the standardized EPA and ASTM test procedures as well as projects involving development of new testing procedures. Performance of all of these projects has involved a leadership role by Scott, from conception and design of experimental approach, through completion of studies and analyses of results, and finally, reporting of the results to the concerned parties.

**EDUCATION:**

| | |
|---|---|
| Ph.D. Ecology (Aquatic Ecotoxicology)<br>University of California, Davis, CA | 1996 |
| M.S. Water Science (Water Pollution Biology)<br>University of California, Davis, CA | 1988 |
| B.S. Fisheries Biology (Water Quality)<br>Humboldt State University, Arcata, CA | 1984 |

**PROFESSIONAL HISTORY:**

| | |
|---|---|
| PACIFIC ECO-RISK LABS, Martinez, CA<br>Principal and Laboratory Director | 1994-Present |
| S.R. HANSEN & ASSOCIATES, Concord, CA<br>Senior Scientist | 1991-1994 |
| UNIVERSITY OF CALIFORNIA, Davis, CA<br>Teaching Assistant (Fish Physiology) | 1991 |
| UNIVERSITY OF CALIFORNIA, Davis, CA<br>Research Assistant | 1986-1991 |
| U.S. FISH & WILDLIFE SERVICE, Dixon, CA<br>Biological Aide | 1985 |

**SCIENTIFIC/RESEARCH AWARDS:**

1989-1990 Pre-Doctoral Fellow, Society of Environmental Toxicology and Chemistry
Best Student Presentation, SETAC, 9th Annual Meeting, 1988.
Jastro-Shields Graduate Research Award, 1986. University of California, Davis.

**EXPERIENCE SUMMARY:**

**Aquatic Toxicology:** Conducted numerous routine effluent and receiving water bioassays (acute and chronic) employing the entire suite of EPA test species, including fish, invertebrates, and algae. Determined pesticide toxicity to a wide variety of organisms as part of developing water quality criteria for several pesticide products. Determined aquatic toxicity of the water soluble fraction of petroleum products. Evaluated the toxicity of petroleum hydrocarbon contaminated sediments, groundwaters, and surface waters. Evaluated impacts of acid-mine drainage surface water runoff to receiving water organisms. Determined effects of water quality variables on selenium toxicity to freshwater and hypersaline organisms. Evaluated interaction of pH and ammonia as a source of refinery effluent toxicity to rainbow trout. Determined effects of selenium on growth and reproduction of fathead minnows. Determined effects of agricultural drainwater on mosquitofish reproduction. Participated in the development of site-specific criteria for copper and nickel in San Francisco Bay.

**Sediment Toxicology:** Directed sediment evaluations as part of ecological risk assessments at most of the Northern California military bases. Directed toxicity evaluations of acid-mine-drainage sediments at SuperFund site. Evaluated the partitioning of contaminants from sediments into porewaters under "in situ" anoxic and oxic conditions. Performed survey of sediment toxicity at sites representing various types of contamination throughout the Sacramento-San Joaquin Valley in California. Prepared literature review and conducted experiments addressing artifactual toxicity in marine and estuarine sediments. Performed sediment toxicity tests in support of ecological risk assessment of lead-contaminated lake sediments. Performed sediment toxicity tests as part of regulatory requirements for marinas. Performed sediment toxicity testing of remediated munitions-contaminated sediments.

**Bioaccumulation Studies:** Performed sediment bioaccumulation tests for remediated munitions-contaminated sediments. Designed and conducted study to evaluate the bioaccumulation of selenium from oil refinery effluent by algal species resident to San Francisco Bay. Determined the effects of water quality variables on selenium bioaccumulation by freshwater and hypersaline organisms. Developed meso-scale food chain (green alga-to-*Daphnia magna*-to-fathead minnows/bluegills) in order to evaluate the roles of bioconcentration and biomagnification in selenium bioaccumulation. Designed and participated in food chain study to evaluate bioaccumulation of selenium from macrophyte detritus by grazing invertebrates.

**Biomonitoring Studies:** Directed numerous ambient water toxicity investigations, including the RMP Baseline toxicity testing and the RMP Episodic Toxicity Study. Supervised the management of the ambient water monitoring for the SRWP. Conducted study to evaluate selenium bioaccumulation trends in San Francisco Bay system by sampling and analyzing resident bivalves from the Sacramento and San Joaquin Delta. Sampled and analyzed water, sediments, and aquatic organisms from numerous evaporation pond systems in San Joaquin Valley. Participated in bivalve biomonitoring study for organics and heavy metals in the Sacramento River and Delta.

**Toxicity Identification/Reduction Evaluations (TI/REs):** Developed and performed chronic TIE using rainbow trout to identify source of toxicity in oil refinery effluent. Designed and conducted bench-scale (physical model) activated carbon treatment to remove refinery effluent toxicity to rainbow trout. Currently developing methods to be used in marine and sediment TI/REs.

**Environmental Chemistry:** Conducted selenium and arsenic analysis of water, sediment, and a wide variety of organismal tissues using atomic absorption spectrophotometry (AAS) coupled with hydride generation. Conducted sodium and potassium analyses of fish tissue and plasma samples using AAS.

**Risk Assessment:** Performed an ecological risk evaluation of hypersaline bittern seepage into sloughs entering South San Francisco Bay. Performed ecological risk assessment of major ions present in treated acid mine drainage runoff. Conducted preliminary risk assessment of trace elements, including selenium, in San Joaquin Valley evaporation pond systems.

**Aquatic Physiological Ecology:** Evaluated effects of temperature on respiration of several fish species resident to the San Francisco Bay and Delta system. Evaluated effects of salinity on hematological characteristics of catfish and sturgeon. Evaluated effects of salinity on osmoregulation and electrolyte regulation in rainbow trout. Evaluated plasma and tissue pH and electrolyte regulation as possible causes for abnormal smoltification in coho salmon.

**Professional Activities:** Assisted in the organization and establishment of the Northern California Regional Chapter of the Society of Environmental Toxicology and Chemistry (NorCal SETAC). Assisted in organizing the First Annual Conference of NorCal SETAC. Organized and served as Meeting Chair for the Second and Third Annual NorCal SETAC Conferences. Served terms as Vice-President and Secretary on the NorCal SETAC Board of Directors.

## PROFESSIONAL AFFILIATIONS:

Society of Environmental Toxicology and Chemistry (SETAC)
Northern California SETAC
Ecological Society of America
American Fisheries Society
American Association for the Advancement of Science

## PEER-REVIEWED PUBLICATIONS:

Ogle RS, Cotsifas JS (in preparation) The role of ammonia in the toxicity of estuarine/marine sediments.

Ogle RS, Thomas B, Rosetta T, Knight AW (in preparation) The sulfate-salinity tolerance of brine shrimp (*Artemia franciscorum*), and the effects of sulfate salinity on selenium uptake.

Cotsifas JS, Ogle RS (in preparation) Salinity tolerance of the aquatic oligochaete *Lumbriculus variegatus*, and the effects of salinity and hardness on metal toxicity.

Ogle RS, Knight AW (in preparation) Selenium in aquatic ecosystems. 3. The roles of waterborne uptake and foodborne uptake in the bioaccumulation of selenate and selenite by fathead minnows and bluegill.

Ogle RS, Knight AW (in preparation) Selenium in aquatic ecosystems. 2. Effects of sulfate on the comparative bioconcentration of selenate and selenite by bluegill and fathead minnows.

Ogle RS, Cotsifas J, Connor V, Foe, C, Deanovic L, Kimball T., Reyes E (2001) A preliminary survey of sediment toxicity in the Sacramento and San Joaquin Delta and selected upstream sloughs and creeks. Manuscripot in preparation.

Ogle RS, Cotsifas JS, Alpers CN, Nordstrom DK (2001) Evaluation of ther toxicity of Acid Mine Drainage depositional sediments at the Iron Mountain SuperFund Site. Manuscript in review: Environmental Toxicology & Chemistry.

Ogle RS, Gunther AJ, Hoenicke R, Bell D, Cotsifas J, Gold J, Salop P (2001) Episodic ambient water toxicity in the San Francisco Estuary. Manuscript in review, Environmental Toxicology Chemistry.

Nordstrom DK, Alpers CN, Coston JA, Taylor HE, McCleskey RB, Ball JW, Ogle S, Cotsifas JS, Davis JA. (1999) Geochemistry, toxicity, and sorption properties of contaminated sediments and pore waters from two reservoirs receiving acid mine drainage. U.S. Geological Survey Water Resources Investigations Report 99-4018A.

Ogle, R.S and A.W. Knight. 1996. Selenium in aquatic ecosystems. 1. Effects of sulfate on selenate uptake and toxicity in *Daphnia magna*. Archives of Environmental Contamination and Toxicology 30(2):274-279.

Bailey FC, Knight AW, Ogle RS, Klaine SJ (1995) Effect of sulfate level on selenium uptake by *Ruppia maritima*. Chemosphere 30(3):579-591.

Saiki, M.K. and R.S. Ogle. 1995. Effects of agricultural drainwater on mosquitofish reproduction from contaminated and control field sites. Transactions American Fisheries Society 124:578-587.

Alaimo, J., R.S. Ogle, and A.W. Knight. 1994. Selenium uptake by larval *Chironomus decorus* from a *Ruppia maritima*-based benthic/detrital substrate. Archives of Environmental Contamination and Toxicology 27(4):441-448.

Williams, M.J., R.S. Ogle, A.W. Knight , and R.G. Burau. 1994. Effects of sulfate on selenate uptake and toxicity in the green alga *Selenastrum capricornutum*. Archives of Environmental Contamination and Toxicology 27(4):449-453.

Brasher, A. and R.S. Ogle. 1993. Comparative toxicity of selenite and selenate to the amphipod *Hyalella azteca*. Archives of Environmental Toxicology and Chemistry 24:182-186.

Maier, K.J., R.S. Ogle, and A.W. Knight. 1988. The selenium problem in lentic ecosystems. Lake and Reservoir Management 4(2):155-163.

Ogle, R.S. and A.W. Knight. 1989. The effects of elevated dietary selenium on growth and reproduction of the fathead minnow (*Pimephales promelas*). Archives of Environmental Contamination and Toxicology 18(6):795-805.

Ogle, R.S., K.J. Maier, P. Kiffney, M.J. Williams, A. Brasher, L.A. Melton, and A.W. Knight. 1988. Bioaccumulation of selenium in aquatic ecosystems. Lake and Reservoir Management 4(2):165-173.

Maier, K.J, C.G. Foe, R.S. Ogle, M.J. Williams, A.W. Knight, P. Kiffney, and L.A. Melton. 1988. The dynamics of selenium in aquatic ecosystems. Pages 361-408 in: Hemphill, D.D. (ed.) Trace Substances in Environmental Health - XXI. University of Missouri Press, St. Louis, MO.

**SELECTED TECHNICAL REPORTS:**

An Aquatic Toxicity Evaluation of Petroleum Hydrocarbon Contaminated Soils for the Saltwater Ecological Protection Zone at the Presidio of San Francisco. Prepared for IT Corporation, Martinez, CA.

Chronic Toxicity Testing of the Shell Martinez Refinery Final Effluent. NPDES Permit Renewal Species Screening - Round 1. Prepared for Shell Martinez Refinery, Martinez, CA.

Evaluation of Algal Growth Potential of Ambient Waters at Laguna de Santa Rosa and Santa Rosa Creeks. Prepared for the City of Santa Rosa, CA.

A Toxicity Evaluation of the Water Accommodated Fraction (WAF) of Petroleum to the Crustaceans
*Mysidopsis bahia* and *Emerita analoga.* Prepared for Hagler Bailly Consulting, Boulder, CO.

"Controlled Atmosphere" Processing of Sediments and Sediment Porewater Extraction for Evaluation of *in situ* Equilibrium Partitioning of Metals from Sediments to Water (at Hamilton AAF). Prepared for IT Corporation, Martinez, CA.

Supplementary Fathead Minnow Toxicity Testing of the City of Santa Rosa's Laguna Wastewater Treatment Plant Effluents and Local Receiving Waters. Prepared for the City of Santa Rosa, CA.
Data Report: San Francisco Estuary Regional Monitoring Program Aquatic Toxicity Testing Results - January 1997. Prepared for the San Francisco Estuary Institute, Richmond, CA.

Evaluation of the Effects of Chlorination/Dechlorination on Chronic Toxicity of the Unocal San Francisco Refinery Final Effluent. Prepared for Unocal San Francisco Refinery, Rodeo, CA.

Toxicity Evaluation of Water and Sediment for the Hercules Gas Plant Remediation Monitoring Program. Prepared for Cal Resources, Bakersfield, CA.

Performance of Sediment Bioaccumulation Tests on the Hercules Gas Plant Remediation Monitoring Program Sediments. Prepared for Cal Resources, Bakersfield, CA.

The Acute Toxicity of Molinate (Ordram®) to Three Freshwater Invertebrates - Comprehensive Final Report. Prepared for Zeneca Ag Products, Richmond, CA.

A Toxicity Evaluation of Sediment and Soil from the Canada de la Heurta. Prepared for California dept. of Fish and Game.

Data Report: San Francisco Estuary Regional Monitoring Program Aquatic Toxicity Testing Results - July 1996. Prepared for the San Francisco Estuary Institute, Richmond, CA.

A Preliminary Survey of Sediment Toxicity in California's Central Valley. Prepared for the Central Valley Regional Water Quality Control Board, Sacramento, CA.

Acute Aquatic Toxicity Evaluation of Caterpillar's Groundwater Treatment Systems. Prepared for Harding Lawson Associates, Oakland, CA.

Aquatic Toxicity Screening of the "Water Accommodated Fraction" Produced From Several Petroleum Products. Prepared for Chevron Research & Technology Co., Richmond, CA.

Generation of Aquatic Toxicity Data for the Development of a Water Quality Criterion for Molinate (Ordram®) for the State of California. Task 2. Development of Toxicity Test Protocol (Standard Operating Procedures) for Selected Test Species. Prepared for Zeneca Ag Products, Richmond, CA.

Data Report: San Francisco Estuary Regional Monitoring Program Aquatic Toxicity Testing Results - February 1996. Prepared for the San Francisco Estuary Institute, Richmond, CA.

Generation of Aquatic Toxicity Data for the Development of a Water Quality Criterion for Molinate (Ordram®) for the State of California: Task 1. Selection of Test Species. Prepared For Zeneca Ag Products, Richmond, CA

Positive Interferences and Artifactual Toxicity in Marine and Estuarine Sediment Toxicity Tests. Prepared for Western States Petroleum Association, Concord, CA.

An Aquatic Toxicity Evaluation of Remediated Munitions-Contaminated Soils/Sediments. Prepared for BioRemediation, Portland, OR.

Toxicity Evaluation of Albany Landfill Leachate: Geographical Heterogeneity and the Role of Ammonia. Prepared for 3E Engineering, Lafayette, CA.

Toxicity Evaluation of Albany Landfill Leachate. Prepared for 3E Eng., Lafayette, CA.

Toxicity Evaluation of Chevron Chemicals "RET" and "OET". Prepared for Chevron Research & Technology Co., Richmond, CA.

Toxicity Evaluation of Ocean-Discharged Effluent from RMC Lonestar Cement Plant. Prepared for RMC Lonestar, Davenport, CA.

Toxicity Evaluation of Wastewater Treatment Options for the Chevron Refinery. Prepared for Chevron USA, Richmond, CA.

Toxicity Evaluation of "Hercules" Site Water Samples. Prepared for McLaren/Hart-ChemRisk Division, Alameda, CA.

Acute and Chronic Toxicity Evaluation of Cargill Salt (Napa River) Pond 7 Bittern to Freshwater and Estuarine Fish and Invertebrates. Prepared for Cargill Salt Co., Newark, CA.

A Critical Review and Evaluation of the Technical Report "Mass Emissions Reduction Strategy for Selenium". Prepared for Western States Petroleum Association, Concord, CA.

Toxicity Evaluation of Chevron CRTC Chemical samples. Prepared for Chevron USA., Richmond, CA.

A Critical Review and Evaluation of the Technical Report "Derivation of Site-Specific Water Quality Criteria for Selenium in San Francisco Bay". Prepared for Western States Petroleum Association, Richmond, CA.

Toxicity Evaluation of Chevron Sample Waters. Prepared for Chevron USA Inc., Richmond, CA.

Chronic Toxicity of Exxon Well Water to the Mysid Shrimp *Mysidopsis bahia*. Prepared for Harding Lawson Associates, Concord, CA.

An Investigation into the Use of Granulated Activated Carbon to Reduce or Remove "Organic" Toxicity from ,Effluent Produced by the Tosco Avon Refinery. Prepared for the Tosco Refining Company, Martinez, CA.

Toxicity Identification Evaluation for Rainbow Trout Toxicity in the Tosco Avon Refinery Effluent. Prepared for the Tosco Refining Company, Martinez, CA.

Evaluation of the Discharge of Cargill Salt Bittern into the EBDA Discharge Line. Prepared for the Cargill Salt Company, Newark, CA.

**PRESENTATIONS:**

Ogle RS (2001) Acute and Chronic Toxicity Testing Issues Associated with NPDES Permits. Presented at the CA Water Environment Association, San Francisco Bay Section, “Toxicity Testing for Dischargers” Workshop, Berkeley, CA, May 23, 2001.

Ogle RS, Gunther A, Cotsifas J, Gold J, Salop P, Bell D, Hansen S, Hoenicke R, Thompson B (2000) Episodic toxicity in the San Francisco Estuary. Presented at the CalFed Bay-Delta Program Science Conference 2000, Sacramento, CA.

Ogle RS and A Gunther (2000) Ambient Water Toxicity Testing in the RMP: (Almost) No News is Good News. Presented at the San Francisco Estuary RMP Annual Meeting,, Oakland, CA, March 13, 1999.

Nordstrom DK, Alpers CN, Coston JA, Taylor HE, McCleskey RB, Ball JW, Ogle S, Cotsifas JS, Davis JA. Geochemistry, toxicity, and sorption properties of contaminated sediments and pore waters from two reservoirs receiving acid mine drainage. Presented at: U.S. Geological Survey Technical Meeting, Charleston, South Carolina, March 8-12, 1999.

Ogle RS and A Gunther (1998) Aquatic Toxicology in the RMP: A story of adaptive management. Presented at the San Francisco Estuary RMP Annual Meeting,, Oakland, CA, February 23, 1998.

Ogle RS (1997) Petroleum and petroleum product toxicity to marine and estuarine organisms. Presented at the Petroleum Hydrocarbon Toxicity Workshop, San Francisco Bay Regional Water Quality Control Board, Oakland, CA, July 2, 1997.

Ogle RS, Cotsifas JS, Barron M, Ricker R, Dugan J (1997) Evaluation of crude oil Water Accommodated Fraction toxicity to marine and estuarine crustaceans. Presented at the NorCal SETAC Seventh Annual Meeting, San Francisco, CA, June 2, 1997.

Ogle RS and JS Cotsifas (1997) Ambient water toxicity in San Francisco Bay. Presented at the San Francisco Estuary Regional Monitoring Program Conference, Oakland, CA. February 13, 1997.

Saiki MK and Ogle RS (1995) Evidence of impaired reproduction in western mosquitofish inhabiting seleniferous agricultural drainwater. Presented at the SETAC 16th Annual Meeting, Vancouver, British Columbia, Canada. November 5-9, 1995.

Ogle, RS, JS Cotsifas, V Connor, and C Foe (1995) A preliminary survey of sediment toxicity in California's Central Valley. Presented at the NorCal SETAC Fifth Annual Meeting, Santa Cruz, CA, July 13, 1995.

Ogle, RS and JS Cotsifas (1994) Ammonia and sediment toxicity. Presented at the Society of Environmental Toxicology and Chemistry 15th Annual Meeting, Denver, CO, Oct 30- Nov 3, 1994.

Ogle, RS (1994) The role of ammonia in marine/estuarine sediment toxicity. Presented at the Northern California Society of Environmental Toxicology and Chemistry 4th Annual Meeting, Oakland, CA, May 20, 1994.

Cotsifas, JS, RS Ogle, and SR Hansen. 1993. Salinity tolerance of the freshwater sediment test oligochaete *Lumbriculus variegatus* and the effects of salinity on the toxicity of Cu, Cd, and Cr. Presented at the Society of Environmental Toxicology and Chemistry 14th Annual Meeting, Houston, TX, Nov. 14-18, 1993.

Ogle, RS, SR Hansen, JS Cotsifas, and GG Wortham. 1993. Selenium bioaccumulation by the clam *Potamocorbula amurensis* in the San Francisco Bay system. Presented at the Society of Environmental Toxicology and Chemistry 14th Annual Meeting, Houston, TX, Nov. 14-18, 1993.

Garcia, MH, SR Hansen, and RS Ogle. 1992. Estimating the chronic marine toxicity of nickel with short-term chronic bioassays. Presented at the Society of Environmental Toxicology and Chemistry 13th Annual Meeting, Cincinnati, OH, Nov. 8-12, 1992.

Ogle, RS, SR Hansen, G Wortham, and DJ Johnston. 1992. A chronic toxicity identification and reduction evaluation of oil refinery effluent discharged into the San Francisco Bay system. Presented at the Society of Environmental Toxicology and Chemistry 13th Annual Meeting, Cincinnati, OH, Nov. 8-12, 1992.

Ogle, RS, SR Hansen, G Wortham, and D Johnston. 1992. A chronic toxicity identification & reduction evaluation of oil refinery effluent discharged into the San Francisco Bay system. Presented at the Northern California Society of Environmental Toxicology and Chemistry 2nd Annual Meeting, Oakland, CA, May 29, 1992.

Ogle RS, Garcia MH, Hansen SR. 1992. Estimating the chronic marine toxicity of nickel with short-term chronic bioassays. Presented at the Northern California Society of Environmental Toxicology and Chemistry 2nd Annual Meeting, Oakland, CA, May 29, 1992.

Ogle, RS and AW Knight. The roles of waterborne uptake and foodborne uptake in the bioaccumulation of selenate and selenite by fathead minnows and bluegill. Presented at the Society of Environmental Toxicology and Chemistry 12th Annual Meeting, Nov. 3-7, 1991, Seattle, WA.

Ogle, RS and AW Knight. The roles of bioconcentration and biomagnification in the comparative bioaccumulation of selenate and selenite by fathead minnows and bluegill. Presented at the Society of Environmental Toxicology and Chemistry - Europe, Founding Conference, April 7-10, 1991, University of Sheffield, Sheffield, England.

Ogle, RS, B Thomas, T Rosetta, and AW Knight. The effects of sulfate on the bioaccumulation of selenium in the brine shrimp *Artemia sp*. Presented at the Society of Environmental Toxicology and Chemistry - Europe, Founding Conference, April 7-10, 1991, University of Sheffield, Sheffield, England.

Ogle, RS and AW Knight. Effects of sulfate on the comparative bioconcentration of selenate and selenite by bluegill and fathead minnows. Presented at the National Symposium on Water Quality, November 12-17, 1989, Orlando, Florida.

Williams, MJ, RS Ogle, RG Burau, and AW Knight. Effects of sulfate on selenate uptake and toxicity in *Selenastrum capricornutum*. Presented at the Society of Environmental Toxicology and Chemistry 10th Annual Meeting, October 28-November 2, 1989, Toronto, Ontario, Canada.

Ogle, RS and AW Knight. Comparative bioconcentration of selenate and selenite by bluegill and fathead minnows. Presented at Society of Environmental Toxicology and Chemistry 10th Annual Meeting, October 28-November 2, 1989, Toronto, Ontario, Canada.

Ogle, RS and AW Knight. Effects of elevated foodborne selenium on the growth and reproduction of the fathead minnow (*Pimephales promelas*). Presented at Society of Environmental Toxicology and Chemistry 9th Annual Meeting, November 13-17, 1988, Arlington, VA. (Best Student Poster Award.)

Ogle, RS and AW Knight. Effects of selenium on the reproduction of an egg-bearing fish, the fathead minnow (*Pimephales promelas*). Presented at 39th American Institute of Biological Sciences Meeting, August 14-18, 1988, University of California, Davis, CA.

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## EDUCATION

University of California, Berkeley (9/81 - 8/86)
M.A. in Geology, December, 1983
Ph.D. in Geology, December, 1986
Ph.D. dissertation: "Geochemical and Geomorphological Dynamics of Supergene Copper Sulfide Ore Formation and Preservation at La Escondida, Antofagasta, Chile"

Harvard University (9/75 - 6/77 and 9/78 - 6/80)
A.B., Magna cum Laude, in Geological Sciences, June, 1980
Senior honors thesis: "Mineralogy, Paragenesis, and Zoning of the Luz Vein, Uchucchacua District, central Peru"

## WORK EXPERIENCE

Research Chemist, GS-14 (9/94 - present)
Research Chemist, GS-13 (9/91 - 9/94)
U.S. Geological Survey, Water Resources Division, California District Office
Sacramento, California

Assistant Professor (1/90 - 9/91)
Department of Geological Sciences
McGill University, Montréal, Québec, Canada

Chemist, GS-12 (9/89 - 12/89)
U.S. Geological Survey, Water Resources Division
Menlo Park, California

Post-doctoral Research Associate (NRC Fellow) (9/87 - 8/89)
Research Advisor - D.K. Nordstrom
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Visiting Assistant Professor (9/86 - 8/87)
Dept. of Geological Sciences
University of Michigan, Ann Arbor

Teaching Assistant (8/83 - 12/83 and 1/86 - 5/86)
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Dept. of Geology and Geophysics
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**WORK EXPERIENCE** (cont.)

Research Assistant (6/82 - 8/83 and 1/84 - 12/85)
Research Advisor - Prof. G. Brimhall
Dept. of Geology and Geophysics
University of California, Berkeley

Exploration Geologist (6/80 - 6/81)
ASARCO, Inc.
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Research Associate (1/78 - 8/78)
Energy and Environmental Analysis, Inc.
Arlington, Virginia

Roughneck (10/77 - 11/77)
Signal Drilling Co.
Rock Springs, Wyoming

**ACADEMIC AND PROFESSIONAL HONORS AND RESPONSIBILITIES**

Guest co-editor, special issue of Chemical Geology on "Sulfate Minerals in Hydrothermal Systems and Low-Temperature Environments", 2001-2002 (in review).

Associate Editor, Economic Geology, 1999-2003

Editor's Citation for Excellence in Manuscript Review, Journal of Environmental Quality, 1997

Post-doctoral Resident Research Associate, National Academy of Sciences/National Research Council, U.S. Geological Survey, 1987-89

Evan Just Award, San Francisco Section of the American Institute of Mining Engineering, 1986

W.W. van Arsdale Fellow, University of California, Berkeley, 1981-82

Dean's List, Harvard College, 1975-76, 1976-77, 1978-79, 1979-80

National Merit Scholar, Harvard College, 1975-76

Class Valedictorian, Natick High School, Natick, Massachusetts, 1975

## PROFESSIONAL REPORTS AND PEER-REVIEWED PUBLICATIONS

Brimhall, G.H, Alpers, C.N., and Cunningham, A.B., 1985, Analysis of supergene ore-forming processes and ground-water solute transport using mass balance principles: Economic Geology, v. 80, p. 1227-1256.

Stoffregen, R.E. and Alpers, C.N., 1987, Woodhouseite and svanbergite in hydrothermal ore deposits: Products of apatite destruction during advanced argillic alteration: Canadian Mineralogist, v. 45, p. 201-211.

Alpers, C.N. and Brimhall, G.H, 1988, Middle Miocene climatic change in the Atacama Desert, northern Chile: Evidence from supergene mineralization at La Escondida: Geological Society of America Bulletin, v. 100, p. 1640-1646.

Alpers, C.N. and Brimhall, G.H, 1989, Paleohydrologic evolution and geochemical dynamics of cumulative supergene metal enrichment at La Escondida, Atacama Desert, northern Chile: Economic Geology, v. 84, p. 229-255.

Alpers, C.N., Nordstrom, D.K., and Ball, J.W., 1989, Solubility of jarosite solid solutions precipitated from acid mine waters, Iron Mountain, California, U.S.A.: Sciences Géologiques, Bulletin, v. 42, p. 281-298.

Alpers, C.N. and Whittemore, D.O., 1990, Hydrogeochemistry and stable isotopes of ground and surface waters from two adjacent closed basins, Atacama Desert, northern Chile: Applied Geochemistry, v. 5, p. 719-734.

Alpers, C.N., Dettman, D., Lohmann, K.C., and Brabec, D., 1990, Stable isotopes of carbon dioxide in soil gas over massive sulfide mineralization at Crandon, Wisconsin: Journal of Geochemical Exploration, v. 38, p. 69-86.

Bussell, M.A., Alpers, C.N., Petersen, U., Shepherd, T.J., Bermudez, C.,and Baxter, A.N., 1990, The Ag-Pb-Zn-Mn skarn, vein, and replacement deposits at Uchucchacua, Peru: studies of structure, mineralogy, metal zoning, Sr isotopes, and fluid inclusions. Economic Geology, v. 85, p. 1348-1383.

Alpers, C.N., Nordstrom, D.K., and Burchard, J.M., 1992, Compilation and interpretation of water-quality and discharge data for acidic mine waters at Iron Mountain, Shasta County, California, 1940-91. U.S. Geological Survey Water-Resources Investigations Report 91-4160, 173 p.

Alpers, C.N., Rye, R.O., Nordstrom, D.K., White, L.D., and King, Bi-Shia, 1992, Chemical, crystallographic, and isotopic properties of alunite and jarosite from acid hypersaline Austalian lakes. Chemical Geology, v. 96, p. 203-226.

Stoffregen, R.E. and Alpers, C.N., 1992, Observations on the cell dimensions, water contents and *D of natural and synthetic alunite: American Mineralogist, v. 77, p. 1092-1098.

Alpers, C.N., and Blowes, D.W. , 1994, Preface: In Environmental Geochemistry of Sulfide Oxidation, Alpers, C.N., and Blowes, D.W. (eds.), ACS Symposium Series, v. 550, American Chemical Society: Washington D.C., p. xii-xiv.

**PROFESSIONAL REPORTS AND PEER-REVIEWED PUBLICATIONS** (cont.)

Alpers, C.N., Blowes, D.W., Nordstrom, D.K., and Jambor, J.L., 1994, Secondary Minerals and Acid Mine-Water Chemistry: In Environmental Geochemistry of Sulfide Mine-Wastes, Jambor, J.L., and Blowes, D.W. (eds.), Mineralogical Association of Canada, Short Course Notes, v. 22, Waterloo, Ontario, p. 247-270.

Alpers, C.N., Nordstrom, D.K., and Thompson, J.M., 1994, Seasonal variations in the Zn/Cu ratio of acid mine drainage from Iron Mountain, California: In Environmental Geochemistry of Sulfide Oxidation, Alpers, C.N. and Blowes, D.W. (eds.) ACS Symposium Series, v. 550, American Chemical Society: Washington D.C., p. 324-344.

Hamlin, S.N., and Alpers, C.N., 1995, Hydrogeology and Geochemistry of Acid Mine Drainage in Ground Water in the Vicinity of Penn Mine and Camanche Reservoir, Calaveras County, California: First-Year Summary: U.S. Geological Survey Water-Resources Investigations Report 94-4040, 45 p.

Hamlin, S.N., and Alpers, C.N., 1996, Hydrogeology and Geochemistry of Acid Mine Drainage in Ground Water in the Vicinity of Penn Mine and Camanche Reservoir, Calaveras County, California: Second-Year Summary, 1992-93: U.S. Geological Survey Water-Resources Investigations Report 96-4257, 44 p.

Rye, R.O., and Alpers, C.N., 1997, The stable isotope geochemistry of jarosite: U.S. Geological Survey Open-File Report 97-88, 28 p.

Alpers, C.N., Hamlin. S.N., and Hunerlach, M.P., 1999, Hydrogeology and Geochemistry of Acid Mine Drainage in Ground Water in the Vicinity of Penn Mine and Camanche Reservoir, California: Summary Report, 1993-95. U.S. Geological Survey Water-Resources Investigations Report 96-4287, 59 p.

Alpers, C.N., and Nordstrom, D.K., 1999, Geochemical modeling of water-rock interactions in mining environments, in Plumlee, G.S., and Logsdon, M.J. (eds.), The Environmental Geochemistry of Mineral Deposits. Part A. Processes, Methods, and Health Issues, Society of Economic Geologists, Reviews in Economic Geology, v. 6A, chapter 14, p. 289-323.

Church, S.E., Alpers, C.N., Vaughn, R.B., Briggs, P.H., and Slotton, D.G., 1999, Use of lead isotopes as natural tracers of metal contamination — A case study of the Penn Mine and Camanche Reservoir, California, in Plumlee, G.S., and Filipek, L. (eds.), The Environmental Geochemistry of Mineral Deposits. Part B. Case Studies, Society of Economic Geologists, Reviews in Economic Geology, v. 6B, chapter 30, p. 567-583.

Nordstrom, D.K., and Alpers, C.N., 1999a, Geochemistry of Acid Mine Waters, in Plumlee, G.S., and Logsdon, M.J. (eds.), The Environmental Geochemistry of Mineral Deposits. Part A. Processes, Methods, and Health Issues, Society of Economic Geologists, Reviews in Economic Geology, v. 6A, chapter 6, p. 133-160.

Nordstrom, D.K., and Alpers, C.N., 1999b, Negative pH, efflorescent mineralogy, and consequences for environmental restoration at the Iron Mountain Superfund site, California, in Smith, J.V.,(ed.), Geology, Mineralogy, and Human Welfare, Proceedings of the National Academy of Sciences, USA, v. 96, p. 3455-3462.

Alpers, C.N., and Hunerlach, M.P., 2000, Mercury contamination from historic gold mining in California. U.S. Geological Survey Fact Sheet FS-061-00, 6 p.

**PROFESSIONAL REPORTS AND PEER-REVIEWED PUBLICATIONS (cont.)**

Alpers, C.N., and Nordstrom, D.K., 2000a, Estimation of pre-mining conditions for trace metal mobility in mineralized areas: An overview, in Proceedings, International Conference on Acid Rock Drainage 2000, May 21-24, 2000, Denver, Colo., Society for Mining, Metallurgy, and Exploration, Inc., Littleton, Colo., p. 463-472.

Alpers, C.N., Antweiler, R.A., Taylor, H.E., Dileanis, P.D., and Domagalski, J.L., 2000, Metals Transport in the Sacramento River, California, 1996-97. Volume 2. Interpretation of Metal Loads. U.S. Geological Survey Water-Resources Investigations Report 00-4002, 106 p.

Alpers, C.N., Jambor, J.L, and Nordstrom, D.K. (eds.), 2000c, Sulfate Minerals: Crystallography, Geochemistry, and Environmental Significance. Mineralogical Society of America and The Geochemical Society, Washington, D.C., Reviews in Mineralogy and Geochemistry, v. 40, 608 p.

Alpers, C.N., Jambor, J.L, and Nordstrom, D.K., 2000d, Preface, in Alpers, C.N., Jambor, J.L, and Nordstrom, D.K. (eds.), Sulfate Minerals: Crystallography, Geochemistry, and Environmental Significance. Mineralogical Society of America and Geochemical Society, Washington D.C., Reviews in Mineralogy and Geochemistry, v. 40, p. iii-iv.

Alpers, C.N., Taylor, H.E., and Domagalski, J.L. (eds.), 2000a, Metals Transport in the Sacramento River, California, 1996-97. Volume 1. Methods and Data. U.S. Geological Survey Water-Resources Investigations Report 99-4286, 428 p.

Cain, D.J., Carter, J.L., Fend, S.V., Luoma, S.N., Alpers, C.N., and Taylor, H.E., 2000, Metal exposure to a benthic macroinvertebrate, Hydropsyche californica, related to mine drainage in the Sacramento River: Canadian Journal of Fisheries and Aquatic Sciences, v. 57, no. 2, p. 380-390.

Jambor, J.L., Nordstrom, D.K., and Alpers, C.N., 2000, Metal-sulfate salts from sulfide mineral oxidation, in Alpers, C.N., Jambor, J.L, and Nordstrom, D.K. (eds.) Sulfate Minerals: Crystallography, Geochemistry, and Environmental Significance. Mineralogical Society of America and Geochemical Society, Washington D.C., Reviews in Mineralogy and Geochemistry, v. 40, p. 303-350.

May, J.T., Hothem, R.L., Alpers, C.N., and Law, M.A., 2000a, Mercury bioaccumulation in fish in a region affected by historic gold mining: The South Yuba River, Deer Creek, and Bear River watersheds, California, 1999. U.S. Geological Survey Open-File Report 00-367, 30 p.

Nordstrom, D.K., Alpers, C.N., Ptacek, C.J., and Blowes, D.W., 2000, Negative pH and extremely acidic mine waters from Iron Mountain, California: Environmental Science & Technology, v. 34, no. 2, p. 254-258.

Nordstrom, D.K., Alpers, C.N., Ptacek, C.J., and Blowes, D.W., 2000, Negative pH and extremely acidic mine waters from Iron Mountain, California: Environmental Science & Technology, v. 34, no. 2, p. 254-258.

Robbins, E.I., Rodgers, T.M., Alpers, C.N., and Nordstrom, D.K., 2000, Ecogeochemistry of the subsurface food web at pH 0-2.5 in Iron Mountain, California, USA: Hydrobiologia. v. 433, p. 15-23.

## PROFESSIONAL REPORTS AND PEER-REVIEWED PUBLICATIONS (cont.)

Seal, R.R. II, Hammarstrom, J.M., Foley, N.K., and Alpers, C.N., 2000a, Geoenvironmental models for seafloor base- and precious-metal massive sulfide deposits: Tools for mitigation and remediation, in Proceedings, International Conference on Acid Rock Drainage 2000, May 21-24, 2000, Denver, Colo., Society for Mining, Metallurgy, and Exploration, Inc., Littleton, Colo., p. 151-160.

Seal, R.R. II, Alpers, C.N., and Rye, R.O., 2000b, Stable isotope systematics of sulfate minerals, in Alpers, C.N., Jambor, J.L, and Nordstrom, D.K. (eds.), Sulfate Minerals: Crystallography, Geochemistry, and Environmental Significance. Mineralogical Society of America and Geochemical Society, Washington, D.C., Reviews in Mineralogy and Geochemistry, v. 40, p. 541-602.

Stoffregen, R.E., Alpers, C.N., and Jambor, J.L., 2000, Alunite-jarosite crystallography, thermodynamics, and geochronology, in Alpers, C.N., Jambor, J.L, and Nordstrom, D.K. (eds.), Sulfate Minerals: Crystallography, Geochemistry, and Environmental Significance. Mineralogical Society of America and Geochemical Society, Washington, D.C., Reviews in Mineralogy and Geochemistry, v. 40, p. 453-479.

Domagalski, J.L., Knifong, D.K., Dileanis, P.D., Brown, L.R., May, J.T., Alpers, C.N., and Connor, V., 2001, Water Quality in the Sacramento River Basin, California, 1995-98. U.S. Geological Survey Circular 1215, 36 p.

Parsons, M.B., Bird, D.K., Einaudi, M.T., and Alpers, C.N, 2001, Geochemical and mineralogical controls on trace element release from the Penn Mine base-metal slag dump. Applied Geochemistry, v. 16, p. 1567-1593.

Roth, D.A., Taylor, H.E., Domgalaski, J., Deleanis, P., Peart, D.B., Antweiler, R.C., and Alpers, C.N., 2001, Distribution of inorganic mercury in Sacramento River water and suspended colloidal sediment material. Archives of Environmental Contamination and Toxicology, v. 40, no. 2, p. 161-172.

## BOOKS EDITED

Alpers, C.N. and Blowes, D.W. (eds.), 1994, Environmental Geochemistry of Sulfide Oxidation. ACS Symposium Series, v. 550, American Chemical Society: Washington D.C., 681 p.

Alpers, C.N., Jambor, J.L., and Nordstrom, D.K. (eds.), Sulfate Minerals: Geochemistry, Crystallography, and Environmental Significance. Mineralogical Society of America and The Geochemical Society, Washington D.C., Reviews in Mineralogy and Geochemistry, v. 40, 608 p.

## PUBLISHED ABSTRACTS, PAPERS IN CONFERENCE PROCEEDINGS, AND PRESENTATIONS AT SCIENTIFIC MEETINGS

Brimhall, G.H, Cunningham, A.B., Alpers, C.N., and Burns, G.J, 1983, Factors controlling supergene enrichment at Butte, Montana and Escondida, Chile: Geological Society of America Abstracts with Programs, v. 15, No. 6, p. 533.

## PUBLISHED ABSTRACTS, PAPERS IN CONFERENCE PROCEEDINGS, AND PRESENTATIONS AT SCIENTIFIC MEETINGS

Stoffregen, R.E. and Alpers, C.N., 1983, The occurrence of aluminum phosphate-sulfate minerals in the advanced argillic alteration assemblage: EOS, Transactions American Geophysical Union, v. 64, No. 45, p. 885.

Alpers, C.N., Brimhall, G.H, Cunningham, A.B., and Burns, P.J., 1984, Mass balance and timing of supergene enrichment at La Escondida, Antofagasta Province, Chile: Geological Society of America Abstracts with Programs, v. 16, No. 6, p. 428.

Cunningham, A.B., Brimhall, G.H, Alpers, C.N., Hampel, J., and Burns, G., 1984, Physical, mineralogical, and chemical effects due to supergene weathering processes at Butte, Montana: Geological Society of America Abstracts with Programs, v. 16, No. 6, p. 480.

Alpers, C.N. and Brimhall, G.H, 1985, Geological constraints on dynamic evolution of supergene copper leaching and enrichment, La Escondida, Chile: poster session presented at Gordon Research Conference on Inorganic Geochemistry of Hydrothermal Ore Deposits, Aug., 1985, Andover, NH.

Petersen, U., Alpers, C.N., Helmericks, M., and Moore, J., 1985, Metal distribution at the Uchucchacua and Atacocha vein and carbonate replacement districts, central Peru: talk presented at National Meeting of American Institute of Mining Engineering, Feb., 1985, New York, NY.

Alpers, C.N. and Barnes, I., 1986, Comparison of chemical and stable isotopic composition of groundwaters and surface waters in two adjacent closed basins, northern Chile: Geological Society of America Abstracts with Programs, v. 18, No. 6, p. 526.

Alpers, C.N. and Brimhall, G.H, 1986, Dynamic evolution of supergene leaching and enrichment: the porphyry copper deposit at La Escondida, Antofagasta, Chile: Geological Association of Canada / Mineralogical Association of Canada,Programs with Abstracts, v. 11, p. 43.

Brimhall, G.H, Dietrich, W.E., Alpers, C.N., and Narasimhan, T.N., 1986, Hydrochemical fractionation patterns of metals by weathering processes: The quantitative interface of subsurface and surficial processes: EOS, Transactions American Geophysical Union, v. 67, No. 16, p. 232.

Alpers, C.N. and Brimhall, G.H, 1987, Middle Miocene climatic desiccation in the Atacama Desert, northern Chile based on geochronology and geomorphology at La Escondida: Geological Society of America Abstracts with Programs, v. 19, No. 7, p. 570.

Alpers, C.N., Nordstrom, D.K., and Ball, J.W., 1988, An evaluation of the solubility product constant of jarosite from oxidized mine waters aged 12 years, Terra Cognita, v. 8, p. 178 (talk presented at Symposium on the Thermodynamics of Natural Processes, July, 1988, Strasbourg, France).

Alpers, C.N., Nordstrom, D.K., and White, L.D., 1988, Solid solution properties and deuterium fractionation factors for hydronium-bearing jarosites from acid mine waters: EOS, Transactions American Geophysical Union, v. 69, No. 44, p. 1480.

**PUBLISHED ABSTRACTS, PAPERS IN CONFERENCE PROCEEDINGS, AND PRESENTATIONS AT SCIENTIFIC MEETINGS** (cont.)

Alpers, C.N., and Nordstrom., D.K., 1989, Mass balance of metal transport during weathering of massive sulfide ores at Iron Mtn., West Shasta Mining District, California: Geological Society of America Abstracts with Programs, v. 21, No. 6, p. A102.

Alpers, C.N., and Nordstrom, D.K., 1990, Stoichiometry of mineral reactions from mass balance of acid mine waters at Iron Mountain, California: Geological Association of Canada / Mineralogical Association of Canada, Programs with Abstracts, v. 15, p. A2.

Alpers, C.N., and Nordstrom, D.K., 1990, Stoichiometry of mineral reactions from mass balance computations for acid mine waters, Iron Mountain, California: In Acid Mine Drainage - Designing for Closure, J.W. Gadsby, J.A. Mallick, S.J. Day, eds., Bi-Tech Pub. Ltd.: Vancouver, B.C., Canada, p. 23-33.

Alpers, C.N., Brimhall, G.H., and Lewis, C., 1990, Mass-balance principles applied to enrichment of base and precious metals in weathering profiles: Proceedings, International Association on the Genesis of Ore Deposits, 7th Meeting, p. 155.

Alpers, C.N., Rye, R.O., and Alpers, C.N., 1990, Low-temperature oxygen isotope exchange between aqueous sulfate and water: Evidence from Lake Tyrrell, Australia: Geological Society of America Abstracts with Programs, v. 22, no. 7, P. A62.

Nordstrom, D.K., Burchard, J.M., and Alpers, C.N., 1990, The production and variability of acid mine drainage at Iron, Mountain, California: A Superfund site undergoing rehabilitation: Geological Association of Canada / Mineralogical Association of Canada, Programs with Abstracts, v. 15, p. A98.

Nordstrom, D.K., Burchard, J.M., and Alpers, C.N., 1990, The production and variability of acid mine drainage at Iron, Mountain, California: A Superfund site undergoing rehabilitation. In Acid Mine Drainage - Designing for Closure, J.W. Gadsby, J.A. Mallick, S.J. Day, eds., Bi-Tech Pub. Ltd.: Vancouver, B.C., Canada, p. 13-21.

Stoffregen, R.E. and Alpers, C.N., 1990, On the unit cell dimensions, water contents, and hydrogen isotopes of natural and synthetic alunites: Geological Association of Canada / Mineralogical Association of Canada, Programs with Abstracts, v. 15, p. A125.

Alpers, C.N., and Nordstrom, D.K., 1991, Evolution of extremely acid mine waters at Iron Mountain, California: Are there any lower limits to pH?, in Proceedings, Second International Conference on the Abatement of Acidic Drainage, Montreal, Quebec, Canada, September 16-18, 1991, MEND (Mine Environment Neutral Drainage): Ottawa, Canada, v. 2, p. 321-342.

Alpers, C.N., Maenz, C., Nordstrom, D.K., Erd, R.C., and Thompson, J.M., 1991, Storage of metals and acidity by iron-sulfate minerals associated with extremely acidic mine waters, Iron Mountain, California. Geological Society of America, Abstracts with Programs, v. 23, No. 5, p. A382.

Nordstrom, D.K., Alpers, C.N., and Ball, J.W, 1991, Measurement of negative pH and extremely high metal concentrations in acid mine water from Iron Mountain, California. Geological Society of America, Abstracts with Programs, v. 23, No. 5, p. A383.

**PUBLISHED ABSTRACTS, PAPERS IN CONFERENCE PROCEEDINGS, AND PRESENTATIONS AT SCIENTIFIC MEETINGS** (cont.)

Alpers, C.N., Nordstrom, D.K., and Thompson, J.M., 1992, Seasonal variations in the Zn/Cu ratio of acid mine drainage from Iron Mountain, California: American Chemical Society National Meetings Book of Abstracts.

Alpers, C.N. and Hamlin, S.N., 1993, Geochemistry and hydrogeology of an acidic ground-water plume in fractured metamorphic rocks at Penn Mine, Calaveras County, California. In EOS, Transactions American Geophysical Union, v. 74, no. 16, April 20, 1993 Supplement, p. 326.

Alpers, C.N., Hamlin, S.N., and Rye, R.O., 1994, Stable isotopes (O,H,S) distinguish sources of acid drainage at Penn Mine, California: Abstracts of the Eighth International Conference on Geochronology, Cosmochronology, and Isotope Geology (ICOG-8), Berkeley, California, June 5-11, 1994, U.S. Geological Survey Circular 1107, Lanphere, M.A., Dalrymple, G.B., and Turrin, B.D. (eds.), p. 4

Alpers, C.N., Bruns, T.R., Cunningham, K.M., Fujimura, R.W, Huang, C., and Finlayson, B.J., 1994, Geochemical, geophysical, and toxicological characterization of metalliferous bottom sediment from Keswick Reservoir, California: Geological Society of America, Abstracts with Programs, v. 26, No. 7, p. A-435.

Alpers, C.N., Cunningham, K.M., Fujimura, R.W, Finlayson, B.J., and Huang, C., 1994, Geochemistry and toxicity of metal-rich sediment and associated pore waters in a reservoir receiving acid mine drainage: Keswick Reservoir, California: EOS, Transactions American Geophysical Union, v. 75, no. 44, November 1, 1994 Supplement, p. 237.

Fujimura, R.J., Huang., C., Finalyson, B.J., and Alpers, C.N., 1994, Toxicity and metal content of reservoir sediments associated with an abandoned copper-zinc mine: American Chemical Society, San Diego, California, March 13-18, 1994.

Hunerlach, M.P., and Alpers, C.N., 1994, Analysis of fracture orientations in surface outcrops and boreholes in the vicinity of an acidic ground-water plume at Penn Mine, Calaveras County, California. In EOS, Transactions American Geophysical Union, v. 75, no. 44, November 1, 1994 Supplement, p. 243.

Nordstrom, D.K., and Alpers, C.N., 1994, The impact of geochemical research on remediation decisions at Iron Mountain, CA: U.S. Department of the Interior, Hazardous Materials Conference 1994, Phoenix, AZ, May, 1994.

Alpers, C.N., 1995, Responsibilities and Activities of the U.S. Geological Survey related to Mining and the Environment. In Workshop Report: Mine Waste Technical Forum, Las Vegas, NV, July 25-27, 1995, U.S. Environmental Protection Agency, Washington, D.C., p. 3-53 to 3-63.

Alpers, C.N., and Bruns, T., 1995, Chemical and physical characterization of metal-rich sediments, Keswick Reservoir, California. U.S. Department of the Interior, Conference on the Environment and Safety, Colorado Spring, CO, April 24-28, 1995.

Hunerlach, M.P., Alpers, C.N., and Hamlin, S.N., 1995, Characterization of ground water contaminated by acid mine drainage at the Penn Mine, California. U.S. Department of the Interior, Conference on the Environment and Safety, Colorado Spring, CO, April 24-28, 1995.

**PUBLISHED ABSTRACTS, PAPERS IN CONFERENCE PROCEEDINGS, AND PRESENTATIONS AT SCIENTIFIC MEETINGS** (cont.)

Nordstrom, D.K., and Alpers, C.N., 1995, Remedial investigations, decisions, and geochemical consequences at Iron Mountain Mine, California: Proceedings of Sudbury '95 - Mining and the Environment. Hynes, T.P., and Blanchette, M.C. (eds.), May 28 - June 1, 1995, Sudbury, Ontario, Canada, CANMET, Ottawa. v. 2, p. 633-642.

Alpers, C.N., and Nordstrom, D.K., 1996, Storage and release of metals, acidity, and oxidation potential by efflorescent sulfate minerals: importance to mine site remediation. Geological Society of America, Abstracts with Programs, v. 28, No. 7, p. A-359.

Alpers, C.N., Rye, R.O., and Nordstrom, D.K., 1996, Stable isotope systematics of S and O in aqueous and mineral sulfates from hyper-acid environments: Chapman Conference on Crater Lakes, Terrestrial Degassing, and Hyper-Acid Fluids in the Environment, Crater Lake, Oregon, September 4-9, 1996.

Nordstrom, D.K., Alpers, C.N., Ptacek, C.J., and Blowes, D.W., 1996, Measurement of negative pH in ultra-acidic mine waters at Iron Mountain, California: Chapman Conference on Crater Lakes, Terrestrial Degassing, and Hyper-Acid Fluids in the Environment, Crater Lake, Oregon, September 4-9, 1996.

Nordstrom, D.K., Alpers, C.N., and Wright, W.G., 1996, Geochemical methods for estimating pre-mining and background water-quality conditions in mineralized areas: Geological Society of America, Abstracts with Programs, v. 28, No. 7, p. A-465.

Rodgers, T.M., Banfield, J.F., Alpers, C.N., and Goodman, R.M., 1996, Microbial weathering of metal sulfides: Initial analysis of bacterial diversity by ribosomal DNA sequencing: Chapman Conference on Crater Lakes, Terrestrial Degassing, and Hyper-Acid Fluids in the Environment, Crater Lake, Oregon, September 4-9, 1996.

Rodgers, T.M., Banfield, J.F., Alpers, C.N., and Goodman, R.M., 1996, Bacterial diversity in acid mine drainage from Iron Mountain, Shasta Co., California: A ribosomal DNA approach: Geological Society of America, Abstracts with Programs, v. 28, No. 7, p. A-35.

Rye, R.O., and Alpers, C.N., 1996, The stable isotope geochemistry of jarosite: Geological Society of America, Abstracts with Programs, v. 28, No. 7, p. A-150.

Alpers, C.N., and Nordstrom, D.K., 1997, Extreme acid mine drainage from Iron Mountain, West Shasta mining district, northern California. The 163rd National Meeting of the American Association for the Advancement of Science - 1997 AAAS Annual Meeting and Science Innovation Exposition, February 13-18, 1997, Seattle, Washington, p. A-40.

Alpers, C.N., Hamlin, S.N., Hunerlach, M.P., and Rye, R.O., 1997, Geochemical and hydrological characterization of acidic ground water zones at the Penn Mine, California: Implications for remediation. Fourth International Conference on Acid Rock Drainage, Vancouver, British Columbia, May 30 - June 2, 1997.

Hunerlach, M.P., Alpers, C.N., Zierenberg, R.A., and Oetker, L., 1997, Underground reconnaissance of acid drainage sources and preliminary evaluation of remedial alternatives at the Copper Bluff Mine, Hoopa Valley Indian Reservation, California: Fourth International Conference on Acid Rock Drainage, Vancouver, British Columbia, May 30 - June 2, 1997.

**PUBLISHED ABSTRACTS, PAPERS IN CONFERENCE PROCEEDINGS, AND PRESENTATIONS AT SCIENTIFIC MEETINGS** (cont.)

Alpers, C.N., and Zierenberg, R.A., 1998, Geoenvironmental characteristics of volcanogenic massive sulfide deposits: In, Short Course Notes, Metallogeny of Volcanic Arcs, British Columbia Geological Survey, Vancouver, B.C., Canada, Open File 1998-8.

Alpers, C.N., Taylor, H.E., Antweiler, R.A., Nordstrom, D.K., Domagalski, J.L., Dileanis, P.D., Cain, D.J., and Unruh, D.M., 1998, Transport, fate, and bioaccumulation of trace metals from a mineralized source area in the Sacramento River Basin, California. Geological Society of America, Abstracts with Programs, v. 30, No. 7, p. A-253 to A-254.

Coston, J.A., Davis, J.A. , and Alpers, C.N., 1998, Partitioning of Cd, Cu, and Zn onto sediments associated with acid mine drainage, Iron Mountain, Shasta County, California. EOS, Transactions, American Geophysical Union, v. 79.

Nordstrom, D.K., Alpers, C.N., Taylor, H.E., Ball, J.W., McCleskey, B., and Ogle, S., 1998, Chemistry and toxicity of pore waters from metal-rich sediments precipitated by mixing of Iron Mountain acid mine waters with Keswick Reservoir, California. Geological Society of America, Abstracts with Programs, v. 30, No. 7, p. A-253.

Parsons, M.B., Bird, D.K., Einaudi, M.T., and Alpers, C.N., 1998, Geochemical and mineralogical controls on trace-element release from base-metal slag deposits at the Penn Mine, Calaveras County, California. EOS, Transactions American Geophysical Union, v. 79, p. A354.

Robbins, E.I., Rodgers,T.M., Nordstrom, D.K., and Alpers, C.N., 1998, Subsurface geochemistry and ecology of the food chain at pH 0-4 in Iron Mt., California, USA: in Abstracts, Chemistry and Ecology of Highly Acidic Environments, University of Durham, United Kingdom, August 16-20, 1998, p. 10-12.

Sanchez, I., Brimhall, G., Swayze, G.A., and Alpers, C.N., 1998, Novel application of digitally integrated mapping systems for the mineralogical characterization of abandoned mines. Geological Society of America, Abstracts with Programs, v. 30, No. 7, p. A-358.

Alpers, C.N., Nordstrom, D.K., Verosub, K.L., and Helm, C.M., 1999, Paleomagnetic reversal in Iron Mountain gossan provides limits on long-term premining metal flux rates. Geological Society of America, Abstracts with Programs, v. 31, No. 6, p. A-33

Antweiler, R.C., Taylor, H.E., Alpers, C.N., and, Domagalski, J.L., 1999, Distribution and transport of selected trace metals in the Sacramento River, July 1996--June 1997. Geological Society of America, Abstracts with Programs, v. 31, No. 6, p. A-34.

Hunerlach, M.P. Rytuba, J.J., and Alpers, C.N., 1999, Mercury contamination from hydraulic placer-gold mining in the Dutch Flat mining district, California. Geological Society of America, Abstracts with Programs, v. 31, No. 6, p. A-64.

Hunerlach, M.P. Rytuba, J.J., and Alpers, C.N., 1999, Mercury contamination from hydraulic placer-gold mining in the Dutch Flat mining district, California, in Morganwalp, D.W., and Buxton, H.T., editors, U.S. Geological Survey Toxic Substances Hydrology Program -- Proceedings of the Technical Meeting, Charleston, South Carolina, March 8-12, 1999, U.S. Geological Survey Water-Resources Investigations Report 99-4018B, p. 179-189.

**PUBLISHED ABSTRACTS, PAPERS IN CONFERENCE PROCEEDINGS, AND PRESENTATIONS AT SCIENTIFIC MEETINGS** (cont.)

Jamieson, H.E, Alpers, C.N., Nordstrom, D.K., and Peterson, R.C., 1999, Substitution of zinc and other metals in iron-sulfate minerals at Iron Mountain, California. Sudbury '99 — Mining and the Environment II, September 12-16, 1999, Sudbury, Ontario, Canada.

Nordstrom, D.K., Alpers, C.N., Coston, J.A., Taylor, H.E., McCleskey, R.B., Ball, J.W., Ogle, S., Cotsifas, J.S., and Davis, J.A., 1999, Geochemistry, toxicity, and sorption properties of contaminated sediments and pore waters from two reservoirs receiving mine drainage, in Morganwalp, D.W., and Buxton, H.T., editors, U.S. Geological Survey Toxic Substances Hydrology Program -- Proceedings of the Technical Meeting, Charleston, South Carolina, March 8-12, 1999, U.S. Geological Survey Water-Resources Investigations Report 99-4018A, p. 289-296.

Parsons, M.B., Bird, D.K., Einaudi, M.T., and Alpers, C.N., 1999, Field, laboratory, and geochemical modeling studies of metal mobility from base-metal slag deposits at Penn Mine, California. Geological Society of America, Abstracts with Programs, v. 31, No. 6, p. A-85.

Sanchez Montero, I., Brimhall, G., Alpers, C., and Swayze, G.A., 1999, Use of UV/VIS/IR spectroscopy to characterize mine waste dumps in Penn Mine, Calaveras County, California. Geological Society of America, Abstracts with Programs, v. 31, No. 6, p. 91.

Taylor, H.E., Roth, D.A., Peart, D.B., Antweiler, R.C., Domagalski, J.L., Dileanis, P., and Alpers, C.N., 1999, Distribution of inorganic mercury in Sacramento River water and sediments. Geological Society of America, Abstracts with Programs, v. 31, No. 6, p. A-101.

(plus several additional abstracts during 2000-01)

**INVITED TALKS, LECTURES, AND SHORT COURSES**

4/85 Department of Geological Sciences, University of Washington, Seattle, WA
2/87 Department of Applied Earth Sciences, Stanford University, Stanford, CA
2/87 Department of Geological Sciences, University of Michigan, Ann Arbor, MI
12/87 Water Resources Division, U.S. Geological Survey, Menlo Park, CA
2/88 Branch of Geochemistry, U.S. Geological Survey, Denver, CO
3/88 Phoebe Apperson Hearst Distinguished Lecture Series, Dept. of Materials Science and Mineral Engineering, University of California, Berkeley, CA
5/88 Department of Geology, University of Montana, Missoula, MT
2/89 Department of Geology, University of Illinois, Champagne-Urbana, IL
2/89 Water Resources Division, U.S. Geological Survey, Reston VA
2/89 Water Resources Division, U.S. Geological Survey, Denver, CO
3/89 Workshop on Acid Groundwaters of Australia (NSF/CSIRO), East-West Center, Honolulu, HI
5/89 Dept. of Geological Sciences, McGill University, Montréal, Québec, Canada
6/90 Dept. of Land, Air, and Water Resources, University of California, Davis, CA
10/90 Dept. of Earth Sciences, University of Waterloo, Waterloo, Ontario
1/92 Hydrogeology Program, University of Nevada, Reno
3/92 Dept. of Geology, University of California, Davis
5/92 Geologic Division, Branch of Geochemistry, U.S. Geological Survey, Denver, CO

**INVITED TALKS, LECTURES, AND SHORT COURSES** (cont.)

4/93 Short Course on Environmental Geochemistry of Mineral Deposits, Society of Economic Geologists, Denver, CO
5/93 Short Course on Geochemical Modeling, American Society for Surface Mining Reclamation, Spokane, WA
5/94 Short Course on Environmental Geochemistry of Sulfide Mine-Wastes, Mineralogical Association of Canada, Waterloo, Ontario
6/94 Mine Tailings Workshop, California Dept. of Toxic Substances Control, Sacramento, CA
9/94 Dept. of Geology and Geophysics, University of California, Berkeley, CA
10/94 Bureau of Land Management, Sacramento, CA
11/94 Dept. of Geology and Geophysics, University of California, Berkeley, CA
11/94 Dept. of Geology, California State University, Sacramento, CA
5/96 Ulrich Petersen Retirement Symposium, Dept. of Earth and Planetary Sciences, Harvard University, Cambridge, MA
10/96 Dept. of Geology, University of California, Davis, CA
11/96 Dept. of Geology and Geophysics, University of California, Berkeley, CA
12/96 Dept. of Earth Sciences, University of California, Santa Cruz, CA
4/97 Dept. of Geology, University of Nebraska, Lincoln, NE
1/98 Short Course on Metallogeny of Volcanic Arcs, British Columbia Geological Survey, Vancouver, B.C., Canada
4/98 Dept. of Geology, California State University, Sacramento, CA
10/98 Sacramento Petroleum Association, Sacramento, CA
10/99 Groundwater Resources Association, Sacramento, CA
10/99 Dept. of Geology, University of California, Davis, CA
11/99 Sierra Nevada Mining and Industry Council, Grass Valley, CA
8/00 Western Region Colloquium, U.S. Geological Survey, Menlo Park, CA
2/01 Dept. of Goelogy, California State University, Sacramento, CA
3/01 Dept. of Geology, California State Universtiy, Chico, CA
4/01 Dept. of Geology, Arizona State University, Tempe, AZ

**PROFESSIONAL MEMBERSHIPS**

American Geophysical Union
Geological Society of America (Hydrogeology Section)
International Association of Geochemistry and Cosmochemistry
Mineralogical Society of America
Society of Economic Geologists
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